

SURGERY

A Monthly Journal Devoted to the Art
and Science of Surgery

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parent that the Mississippi Valley is the largest area, geographically if not in numbers of population. In this great tract of country between the Rockies and the Alleghenies, SURGERY will become, to some extent at least, the organ of clinical surgery of the Middle West; and yet it will not be local in any respect, but an organ of the world's surgical thought. This journal, brought out by a well-known medical publishing house, will receive the ethical supervision which is characteristic of American medical journals of the highest class.

SURGERY has two editors. Dr. Alton Ochsner, the distinguished American surgeon, Head of the Department of Surgery at Tulane University, New Orleans, has won for himself an international reputation. Dr. Owen H. Wangensteen, Professor of Surgery and Head of the Department of Surgery of the Medical School of the University of Minnesota, has made splendid contributions, not only to clinical surgery, but to scientific investigation.

Associated with Dr. Ochsner and Dr. Wangensteen in SURGERY are two associate editors. Dr. Alfred Blalock, Associate Professor of Surgery at Vanderbilt University, is one of the leaders of surgical thought in the South. Dr. William F. Riehoff, Jr., Associate Professor of Surgery at Johns Hopkins Medical School, has made splendid contributions to surgical progress, and is a worthy representative of the Hopkins school of advanced medical thought.

In addition to the distinguished editors and associate editors, SURGERY is fortunate in its Advisory Council of nine members, its Editorial Board of sixteen members, and its Committee on Publications of forty members, an extraordinary roster of able and distinguished members of the surgical profession of America.

It is pleasing that the editors of SURGERY are representative of the southern and the northern extremes of the great Mississippi Valley. With expanding traffic on the Mississippi River and its tributaries as the result of the growing exchange of commodities by boat and barge with Mexico and Central and South America, through the port of New Orleans, which is second only to that of New York in shipping, the Middle West will be brought increasingly into contact with tropical diseases of various types, as the Atlantic seaboard and the Pacific seaboard already have been exposed to these diseases. We know that tropical diseases are being brought farther and farther north as their bacterial and insect carriers are becoming acclimatized to the conditions of the North Temperate Zone. The study of the cause and treatment of these diseases must constitute henceforth a part of the medical curriculum. Mexico and Central and South America have much of scientific value to give to the medical profession of the United States. The Latin American surgeons of the earlier day were trained largely in the French schools, and contributed greatly to the advancement of surgery. One who visits the medical schools, clinics,

and hospitals of Latin America will be interested and impressed, as I have been, by the high character of these physicians and surgeons and their contributions to medical and surgical thought. We of the profession in the United States will welcome increasing cooperation with our learned confreres of Mexico and Central and South America.

When this war-torn world has settled down again, shall we not find that American money, American inventions, and American scientific instruments of various kinds have added greatly to Europe's ability to provide for herself economically? Japan at the present time apparently is master of the Orient. But the countries to the south of us are an open field, affording a vast opportunity for mutual usefulness, economically as well as educationally and scientifically. SURGERY can do much to advance the exchange not only of surgical knowledge but also of social and economic thought and practice which may be of the greatest reciprocal value.

The idea of SURGERY appeals to my brother, Dr. Charles H. Mayo, and me, to our spirit and imagination. We know of the great numbers of young surgeons who will be interested in this venture and will profit by it. Speaking for ourselves, when we have written medical articles, we have profited more than the readers, because in the preparation we have been obliged to look up many scientific matters with which otherwise we might have been unfamiliar. The new journal of surgery will fulfill a useful purpose. It will stimulate the younger men to write, and in the writing they, even more than their confreres, will gain; above all, it will disseminate scientific surgical knowledge which will aid in the care of the sick.

A handwritten signature in dark ink, reading "W. J. Mayo". The signature is written in a cursive, flowing style with a large, prominent "M".

EDITORIAL ANNOUNCEMENT

THE growth of medical knowledge during the time which parallels the development of the new science of bacteriology has been unprecedented in the annals of medical history. The employment of a new approach to old problems succeeded overnight in differentiating with precise methods what centuries of speculation and plodding effort had failed to do. Medical journals multiplied to record the successive discoveries and conquests. New and unfamiliar specialties of practice sprang into being to assail disease in the interphases between medicine, chemistry, and physics.

The number of recognized specialties in the broad field of medicine has become so large as to impose a great task on anyone who should attempt to enumerate them all. The problem of relating the gains in skill and knowledge of any of these groups to the others has obviously become intricate and difficult. A method which will serve to coordinate more intimately these newly gained increments of enlightenment and bring their advantages to the practical man of medicine is highly desirable.

There can be no longer a sharp distinction between that which is medical and that which is surgical. The borders between medicine and surgery are not fixed, but are constantly changing. There is a continual striving to find means of treating surgically diseases which are refractory to medical management; at the same time an uninterrupted search is always in progress for conservative agents which may adequately replace satisfactory, but more energetic, operative methods. The sole anxiety of surgery is no longer concerned with the treatment of wounds. Surgery has emerged from a handicraft to occupy an important position in the treatment of disease. Its influence has been felt in every branch of medical science and practice.

Indispensable as the surgeon has become to society and his medical confreres, even more dependent is he upon the life-giving spirit of close association with fellow workers in the broad domain of medicine. Surgeons are not long the best company for one another. There is only enough sustenance in a purely surgical fare for subsistence; for growth, a free admixture of the vitalizing ingredients of other forces of medicine is essential. "Man shall not live by bread alone," and surgeons cannot thrive on the lone products of their own efforts.

In essence, SURGERY is an attempt at integrating more effectually the many interphase activities of the surgeon. The need has become great for a more intimate correlation between the increasingly divergent medical and surgical specialties. No group can suffer isolation long without

revealing unmistakable signs of want. The superiority of the medical assembly in which different points of view are brought to bear upon a subject of common interest is becoming more generally recognized. Witness the developments which have recently occurred in the province of thoracic surgery through the fusion of various branches of specialized medical knowledge. Obviously, it is a far simpler task to effect such a correlation for one province of surgery; yet, so far as is practicable, an endeavor to achieve the same purpose in the wider scope of general surgery appears meritorious. A large number of individuals of diverse training and interests have lent their talent and willing hands to this enterprise to help secure that end.

The columns of *SURGERY* invite concise papers of new matter relating to the broad field of surgery, its specialties and interphases with other provinces of medical practice and science. To authors, *SURGERY* will aim to assure early publication of original matter; to readers, it will strive to bring a digest of what is new and best in surgery and its frontiers.

The importance of the stimulus which splendid surgical journals of this and other countries have lent sound practice is inestimable. The pages of *SURGERY* will be dedicated to the ideal which they typify—the improvement and advance of surgery.

Alton Ochsner

Owen H. Wangensteen

Original Communications

THE SURGICAL TREATMENT OF SCLERODERMA

RATIONALE OF SYMPATHECTOMY AND PARATHYROIDECTOMY

(BASED UPON EXPERIMENTAL INVESTIGATIONS AND A CLINICAL STUDY OF
26 PERSONAL CASES)

RENE LERICHE, ADOLPHE JUNG, STRASBOURG, FRANCE,
AND MICHAEL DE BAKEY,* NEW ORLEANS, LA.

(From the Surgical Clinic A, Director: Professor Rene Leriche, Strasbourg, France)

THE ideal and trend of modern surgery may be characterized by the continuous search for a more ratiocinative comprehension of the less obvious alterations in physiologic functions consequent to the more apparent anatomicopathologic processes. This is readily evinced by the ever-increasing number of previously considered nonsurgical diseases, which in the past decade have entered the widening realms of surgical endeavor. A recent characteristic example of this form of progress is the considerable attention which scleroderma has received from surgeons throughout the world. Until relatively recently this disease has been considered a purely dermatologic condition gladly relegated to that specialty.

Scleroderma is the term applied to the syndrome characterized by sclerosis, induration, and pigmentation of the skin which may be localized or generalized and frequently associated with asthenia, digestive disturbances, arthritis, muscle atrophy, and other symptoms depending upon the gravity and degree of involvement. The profound and voluminous literature already amassed in a comparatively short period of time is clearly indicative of the existing confusion and bewilderment concerning the etiology and pathogenesis of this disease. It would be inexpedient as well as inopportune to attempt here a detailed review of this phase of the subject. Even at the risk of being invidious, we prefer to confine this presentation to a discussion of the surgical therapeutic considerations as based upon our experimental investigations and clinical observations of twenty-six cases.

There are at present two available procedures in the surgical treatment of scleroderma: sympathectomy and parathyroidectomy. This in itself aptly, if trenchantly, suggests the confusion that exists in the etiology and pathogenesis of the condition. Both procedures, however, are based upon a rational consideration of certain facts and observations which seem to have pathogenic significance.

*On leave of absence, Department of Surgery, Tulane University Medical School, New Orleans, La.

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THEORETIC BASES FOR SURGICAL MEASURES APPLIED TO THE SYMPATHETIC APPARATUS

It has long been observed that there is a certain type of scleroderma which in its onset closely resembles a mild or atypical Raynaud's disease. As a matter of fact, in a large number of cases the diagnosis first made is Raynaud's disease, and subsequently the characteristic dermatologic features appear and the diagnosis is then changed to scleroderma. Kaufman¹ states that the symmetrical type of scleroderma, usually confined to the extremities, often begins with symptoms of Raynaud's disease; and O'Leary and Nomland² in a clinical study of 103 cases of scleroderma found that there was an antecedent vasomotor disturbance in over one-third. We have noted this same phenomenon in the majority of cases which we have observed.

Aside from the fact, however, that in a large number of cases of scleroderma there is a preceding history of vasomotor disturbances closely simulating Raynaud's disease, there are other facts which lend support to this conception of its pathogenesis. Although there has been a paucity of necropsy examinations in the study of scleroderma, nevertheless the histopathologic investigations that have been made show definitive changes in the arterioles and capillaries in certain forms of scleroderma. Matsui³ reported detailed examinations of six patients and found definite changes not only in the small cutaneous arteries but also similar degenerative changes in the lungs, kidneys, and endocrine glands. As a result of these studies, he opined that scleroderma was probably a manifestation of endocrine dysfunction. Sannicandro⁴ also noted these pathologic manifestations. Although Brown, O'Leary, and Adson⁵ made similar observations in sections of skin studied, they state, however, that there was considerably more cellular infiltration both within and around the small cutaneous vessels in those patients with the vasomotor type of scleroderma. An endarteritis of the peripheral vessels was also reported by Rake⁶ in the case which he studied in detail and which was of the vasomotor type.

The interesting observations made by Brown and O'Leary⁷ and Brown, O'Leary, and Adson⁵ are especially noteworthy in this respect. In their microscopic studies of the capillaries in the nailfold, they found a marked diminution in the number of open capillaries for each unit area of skin, with definite disturbances in the flow of blood through the loops. Slight lowering of environmental temperature produced slowing or even an arrest in the flow of blood, thus reflecting the exaggerated tonus of the arterioles. They came to the conclusion that the diminished vascularity of the skin in certain forms of scleroderma was due not only to the occlusive disease of the smaller vessels but also to the significant factor of sympathetic hypertonia of the arterioles. One of us⁸ with Fontaine, in 1929, showed by oscillographic studies this characteristic vasospastic element in certain forms of scleroderma. The oscillographic

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indices demonstrated very clearly the marked influence of environmental temperature, so typical of Raynaud's disease. The observations reported by Johnson and Hedges⁹ are also of interest in this regard. They reported a case of Raynaud's disease complicated with scleroderma and sclerodactylia in which they made circulatory studies with a special finger plethysmograph. Their investigations demonstrated that the circulation was persistently less than normal in the fingers, even in the absence of an attack, and that peripheral vasodilation could be induced with local heat.

In recapitulation, the rationale for the conception that the sympathetic apparatus is of pathogenic significance in certain forms of scleroderma, and therefore sympathectomy is indicated as a therapeutic procedure, is based upon the following facts and observations: In a large number of cases of scleroderma the onset is characterized by vasomotor disturbances which so closely resemble Raynaud's disease that this diagnosis is frequently made. Clinical corroboration of this vasospastic element is demonstrated by the spontaneous improvement which often follows febrile reactions and the transportation of these patients to warmer climates. Histopathologic studies clearly reveal definitive vascular changes, and the pronounced influence of the environmental temperature upon the flow of blood in the skin is confirmatory evidence of the pathologic hypertonia of the arterioles.

CLINICAL CONSIDERATIONS OF SYMPATHECTOMY

Because clinical observations indicated that there was a vasospastic element in certain forms of scleroderma one of us,¹⁰ in 1922, proposed the interruption of sympathetic fibers to the vessels as a therapeutic procedure in this form of the disease. The first practical realization of this method of treatment was made by Brüning.¹¹ Other reports followed by Enderlen,¹² Horn,¹³ Kappis,¹⁴ Stahl,¹⁵ Kment,¹⁶ Lehmann,¹⁷ Müller,¹⁸ and more recently by Adson, O'Leary, and Brown.¹⁹ As is usually the case when a new procedure is quickly adopted before a more rational comprehension of the underlying physiologic principles is developed, the results have been varied and contradictory. Some reported brilliant results, while others observed complete failures. On December 5, 1924, one of us with Fontaine²⁰ performed our first sympathectomy upon a patient with scleroderma, which resulted in definite improvement. Since then we^{8, 21, 22} have performed others, which are reported elsewhere in detail. We present here a brief summary, with follow-up reports, of all the cases we have performed up to the present time in this clinic.

CASE 1.—Woman, fifty-six years of age. For thirteen years she had had symptoms of sclerodactylia and gout. Skin of face and neck was atrophied; skin of hands was thick, indurated, tense, and painful, and there was stiffness of the joints of the fingers. Various forms of medical treatment had failed. Following bilateral

perihumeral sympathectomy on Dec. 5, 1924, there was complete relief of pain, the skin of the hands became more flexible, and mobility of the joints increased. In April, 1925, right cervical sympathectomy and ramisection were performed on the left side. Following this, the skin of the face and neck became hyperemic and more flexible and the condition of the hands continued to improve. When last examined, April, 1929, four years after last operation, the skin of the face, neck, and hands had maintained the same improvement, but the gout was not influenced.

CASE 2.—Woman, forty-six years old. During the past two years scleroderma of the face, neck, and hands had developed. Finger joints were almost immobile. On May 5, 1925, left cervical ramisection was performed. Two weeks later the same procedure was followed on the right side, together with bilateral perihumeral sympathectomy. Following this, the skin of the hands, which had previously been cold and cyanotic, became warm and had a more normal color. The skin of the face and neck became more flexible and the joints of the fingers were more mobile. When reexamined in 1934, nine years later, the patient appeared completely cured. Skin of face, neck, and hands was normal and joints had regained total mobility.

CASE 3.—Woman, fifty-four years old. For the past twenty years she had had vasomotor disturbances in the hands and feet, resembling Raynaud's disease. Two years previous to admission to the hospital, she noted areas of redness and induration of the skin of the left leg and later similar areas on the right leg and upper extremities. On examination, sclerodermatous changes were observed on both upper and lower extremities with slight involvement of the face. Right cervical sympathetic ramisection was done on June 5, 1925, and on June 24, left perihumeral sympathectomy. Following these operations there was hyperemia, and the skin of the right upper and left lower extremities became less tense and indurated, pain disappeared, and the joints of the fingers were more mobile. In 1929, four years after operation, the patient wrote that she still retained the same degree of improvement.

CASE 4.—Woman, twenty years old. Condition began two years previously, with redness and induration of the skin, and arthralgia. On examination, it was observed that she had pronounced generalized scleroderma with involvement of almost all the joints. Opening her mouth was extremely difficult, and there was almost complete immobilization of the joints of the hands, wrists, and elbows. On June 20, 1928, left cervical sympathectomy was performed and five days later the operation was repeated on the right side. Ten days later the patient was dismissed from the hospital; at that time the skin of the face had shown some improvement and the patient could open her mouth much more easily. Six months later the mother wrote that there was apparently no amelioration.

CASE 5.—A woman, forty-nine years of age, had marked generalized scleroderma, immobilization of nearly all joints, cataracts, and digestive disturbances. She had considerable pain in her hands, which were cyanotic and cold. Extirpation of the right cervical sympathetic chain on Dec. 7, 1928, gave no improvement.

CASE 6.—Woman, fifty-three years of age. Four years previous to admission, she began having vasomotor disturbances in her hands, resembling Raynaud's disease. Shortly afterward sclerodermatous changes developed which at the time of examination involved the face, neck, upper part of chest, hands, and forearms. There was some pigmentation on the dorsum of the hands, with partial immobilization of the finger joints. Blood calcium was 0.126 (Hirth). Radiographic studies revealed marked osteoporotic changes in the phalanges, carpal bones, and lower part of the radius and ulna. Following resection of the left inferior cervical ganglion on Feb. 24, 1933, there was definite improvement in the skin of the left hand and left side of the face, with increase in mobility of the fingers on the left hand. After resection of the right cervical sympathetic chain on Feb. 16, 1934, there was similar

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up to the thighs and in the upper extremities, but more pronounced on the right side. Limitation of motion of the shoulder and elbow joints. On Dec. 2, 1933, left lumbar sympathectomy was performed. Following the operation improvement was such as to justify similar procedure on the right side, which was performed on Jan. 26, 1934. Similar improvement in the skin condition was noted. On Feb. 12, 1934, a resection of the right inferior cervical sympathetic ganglion was followed by definite amelioration in the right upper extremity and right side of the face. On March 2, 1934, a similar operation was performed on the left side. On Sept. 8, 1934, the patient was reexamined and marked improvement was still present.

CASE 13.—A woman, thirty-nine years old, had complained for two years of vasomotor disturbances in her fingers and toes, resembling atypical Raynaud's disease. For the past several months she had also noted sclerodermatous changes involving her face, neck, and hands. Following right inferior cervical sympathetic ganglionectomy on July 11, 1934, and a similar procedure on the left side ten days later, there was definite improvement on both sides. By Nov. 10 the condition was much improved. She was able to return to work as a piano teacher. When it became cold, however, she had slight vasomotor disturbances.

COMMENT

Of the 13 cases in which sympathectomy has been performed there was marked improvement in 5, 38.4 per cent, moderate improvement in 4, 30.7 per cent, slight improvement in 1, 7.6 per cent, and no improvement in 3, 23 per cent. It may be said in general that approximately two-thirds of the cases show some degree of improvement, and this reflects the general consensus. Mayo and Adson²³ arbitrarily divided their cases of scleroderma into three groups, depending upon whether the vasomotor phenomena preceded the disease, appeared simultaneously, or developed later. The greatest percentage of improvements following sympathectomy was obtained in the first group. They stress the importance of selecting those cases of scleroderma which show pronounced vasospastic phenomena, especially preceding the cutaneous manifestations. This is undeniably an important factor, and the best results will be obtained in that group of cases which might be termed the Raynaud-scleroderma syndrome. Even in this form of the disease, however, complete failures are not infrequent. One of our cases was characteristic of this type of scleroderma and after sympathectomy showed no improvement. Even in the others in which there was no improvement, vasomotor disturbances were definitely present. In the generalized, advanced cases sympathectomy is of little or no avail. Those cases most suitable for sympathectomy are the early ones in which the cutaneous lesions are not pronounced, in which the joints are not severely involved, and in which vasospastic phenomena are a conspicuous feature.

THEORETIC AND EXPERIMENTAL BASES FOR PARATHYROIDECTOMY

That a disturbance in the equilibrium of the sympathetic apparatus is not the only factor of pathogenic significance in scleroderma appears to be an ineluctable fact. It is obvious that there is a vasospastic ele-

improvement on the right side. Mouth could be opened much better. In December, 1935, examination revealed that the patient continued to show the same degree of improvement.

CASE 7.—A woman, fifty-two years old, had suffered for ten years with characteristic vasomotor disturbances of Raynaud's disease. Recently she began to develop sclerodermatous changes in her hands. On April 10, 1933, extirpation of the right inferior and middle cervical ganglions was performed. Examination in December, 1935, revealed no evidence of scleroderma in the extremities and the patient has had no more vasomotor disturbances, but sclerodermatous changes were definitely present on the thorax and abdomen. This case clearly demonstrates the futility of sympathectomy in the generalized form.

CASE 8.—Woman, fifty-one years of age. Four years previously she noted slight induration and pigmentation of the skin of all extremities. Later vasomotor disturbances developed in her fingers. Examination showed marked generalized scleroderma of the face, neck, chest, and extremities, with pigmentation on the hands. Finger joints were almost completely immobilized. Wrists were also involved, with considerable pain. The lower extremities were less involved. Radiograms revealed osteoporotic changes in the phalanges and carpal bones. On April 6, 1933, resection of the right inferior and middle cervical ganglions was done, but there was no improvement immediately after the operation. Patient died suddenly on April 29, 1934, and autopsy revealed pneumonia and adhesive pericarditis.

CASE 9.—A woman, forty-three years of age, had complained for three years of vasomotor disturbances in the hands, feet, and nose. Sclerodermatous changes began two years later, especially marked in the hands, forearms, and face, with less involvement in the lower extremities, and pigmentation. There was stiffness of the wrist and finger joints, and considerable pain. Right cervical sympathectomy on June 14, 1933, caused very little improvement afterward. Examination on Feb. 17, 1935, showed no improvement.

CASE 10.—A woman, forty years of age, had complained for the past nine years of vasomotor disturbance in her fingers and toes, resembling Raynaud's disease. Shortly after this began she noted sclerodermatous changes with pigmentation, which at present is almost generalized. There was involvement of the joints of the upper extremities, with considerable pain. Calcemia 0.100 (Hirth). After resection of the right inferior cervical sympathetic ganglion on Sept. 8, 1933, there was moderate improvement in the condition of the right upper extremity and both lower extremities. In May, 1934, this same degree of amelioration was still present.

CASE 11.—Woman, twenty-eight years of age. For four years she has had vasomotor disturbances typical of Raynaud's disease. For the past two years sclerodermatous changes have developed, which at the time of examination were most marked in the face, neck, forearms, and hands, with pigmentation and limitation of motion in the joints of the fingers, wrist, and elbow. Blood calcium 0.109 (Hirth). On July 22, 1933, resection of the right inferior cervical sympathetic ganglion was done. Five days later, there was definite improvement in the condition of the skin and mobility of the joints on that side. On Aug. 4, 1933, a similar operation was performed on the left side. An examination, Nov. 9, 1934, showed marked improvement. Pigmentation had disappeared. The skin of the face, neck, and upper extremities was more flexible, warm, and pink. Movement of joints was considerably improved, and vasomotor disturbances had disappeared.

CASE 12.—Woman forty-two years of age. Four years before admission she began to complain of vasomotor disturbances which were not typical of true Raynaud's disease. Shortly afterward sclerodermatous changes developed. On examination, scleroderma with pigmentation was found most marked in the lower extremities

up to the thighs and in the upper extremities, but more pronounced on the right side. Limitation of motion of the shoulder and elbow joints. On Dec. 2, 1933, left lumbar sympathectomy was performed. Following the operation improvement was such as to justify similar procedure on the right side, which was performed on Jan. 26, 1934. Similar improvement in the skin condition was noted. On Feb. 12, 1934, a resection of the right inferior cervical sympathetic ganglion was followed by definite amelioration in the right upper extremity and right side of the face. On March 2, 1934, a similar operation was performed on the left side. On Sept. 8, 1934, the patient was reexamined and marked improvement was still present.

CASE 13.—A woman, thirty-nine years old, had complained for two years of vasomotor disturbances in her fingers and toes, resembling atypical Raynaud's disease. For the past several months she had also noted sclerodermatous changes involving her face, neck, and hands. Following right inferior cervical sympathetic ganglionectomy on July 11, 1934, and a similar procedure on the left side ten days later, there was definite improvement on both sides. By Nov. 10 the condition was much improved. She was able to return to work as a piano teacher. When it became cold, however, she had slight vasomotor disturbances.

COMMENT

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That a disturbance in the equilibrium of the sympathetic apparatus is not the only factor of pathogenic significance in scleroderma appears to be an ineluctable fact. It is obvious that there is a vasospastic ele-

ment, but the true etiology and pathogenesis remain yet unknown, and search must be made in another direction to determine what other factors play prominent rôles.

In 1929, Pautrier and Zorn²⁴ made a signal observation. They found a hypercalcemia in all of the 6 cases which they studied. Almost simultaneously Naegeli²⁵ made similar observations in 20 cases which he had studied. Michon and Bohême²⁶ noted an increase in blood calcium in 48 of 65 cases. One of us with Chinassi Hakki^{27, 28} found hypercalcemia in 7 of 10 cases, and up to the present time in 20 cases of scleroderma which we have examined, the blood calcium was found to be: between 0.100 and 0.115 in 13 cases; between 0.89 and 0.099 in 4 cases; and between 0.087 and 0.088 in three cases.* Since then hypercalcemia in scleroderma has been reported by Milian et al.,²⁹ Weissenbach et al.,³⁰ Kennedy,³¹ Pernet,³² and others. On the other hand, hypercalcemia is not a constant finding and cases have been observed in which the blood calcium was normal or even below normal. In this latter group belong the cases cited by Durham,³³ Michon and Bohême,²⁶ and Lereboullet and Lelong.³⁴ Because these investigators have observed a normal or even subnormal blood calcium in patients with scleroderma, they have attempted to show that the hypercalcemia found in scleroderma is of little or no significance. We insist on the fact, however, that this does not depreciate the significance of hypercalcemia in scleroderma. Experimental investigations have shown that in chronic hyperparathyroidism the hypercalcemia is only temporary. Jaffe and Bodansky³⁵ have shown that in hyperparathyroid dogs the blood calcium is at first increased, but after a certain period of time, occasionally within three or four months, the blood calcium drops to normal and remains there in spite of the fact that the dogs are still in a state of hyperparathyroidism. We have observed this same phenomenon. In chronic hyperparathyroidism the hypercalcemia does not necessarily persist, and one is not justified in concluding that a parathyroid dysfunction does not exist in scleroderma simply because normal or subnormal blood calcium findings have been observed. Scleroderma should be considered not as an acute but rather as a chronic disturbance in parathyroid function, evolving over a long period of time, and when the patient is finally observed, the manifestation of hypercalcemia may no longer be present. Studies of the urinary calcium have revealed no significant changes which do not correspond with the blood findings.

The investigations which have been made upon the cutaneous changes occurring in experimental hyperparathyroidism are of considerable importance, and strengthen the theory that the parathyroids play a prominent rôle in scleroderma. In 1932, Selye³⁶ reported that the injection

*These determinations and all others given here were made by the procedure of Hirth, for which the normal figures are 0.059 and 0.022.

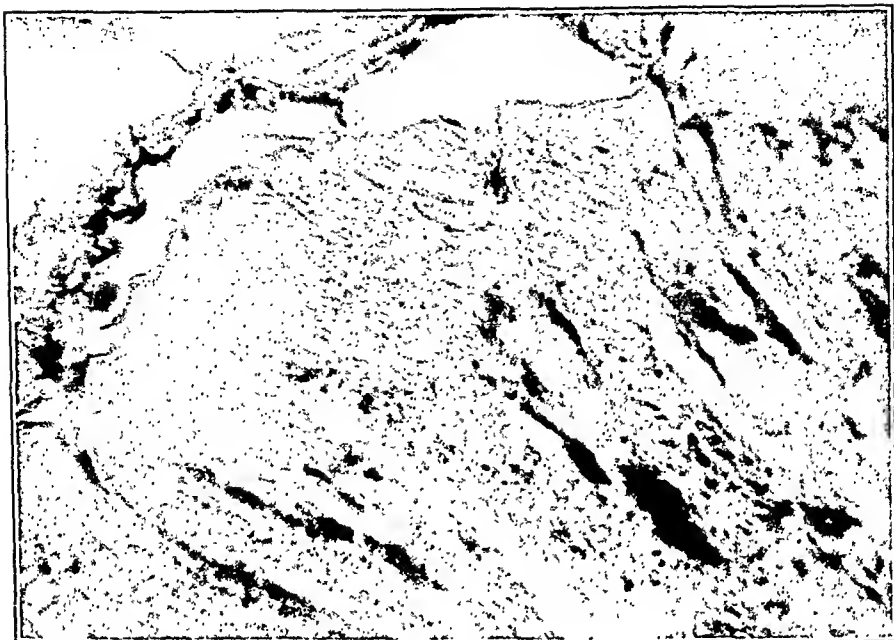


Fig. 1.—Photomicrograph of section of skin of a rat (two weeks old) which received 4 units of parathormone daily for four days. Haemalum-erythrosin-saffron stain. Note thinning of epidermis and degeneration of corium. (Collagen fibers indistinct. Pyknotic nuclei and sebaceous glands partially destroyed.)

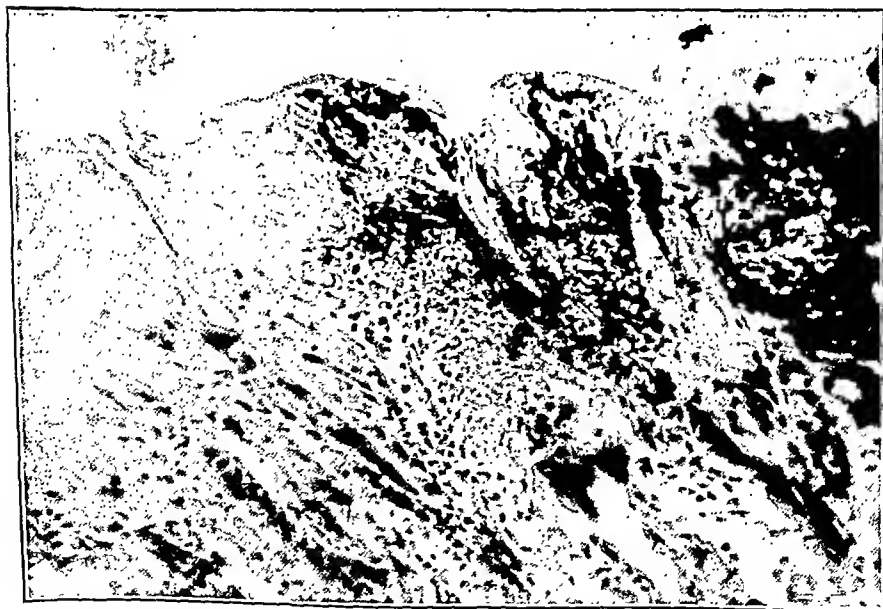


Fig. 2.—Photomicrograph of section of skin of same rat as shown in Fig. 1. Silver nitrate stain (de Kossa), showing marked calcium deposition in corium.

of parathormone in young rats, from one to two weeks old, produced cutaneous changes which anatomically resembled scleroderma, and in 1933 Shelling, Asher, and Jackson³⁷ confirmed these findings. With Sureyya³⁸ we made somewhat similar experimental studies and found that the injection of parathormone (Collip) in young rats (one to two weeks old) produced: (1) a marked arrest in growth; (2) thickening and induration of the skin with pronounced loss of hair; (3) an increase in the water content of the skin; (4) an increase of the calcium content of the skin of from two to three times the normal; (5) on histologic examination changes in the skin characterized by destruction and scar tissue, infiltration of the dermis with marked calcium deposition, and a pronounced atrophy and exfoliation of the epidermis. (Figs. 1 and 2.) These changes, however, seem to be transitory, because if the examinations are made later than several days after the injections, none of these manifestations can be demonstrated. Nevertheless, these findings indicate that cutaneous changes, which clinically and histologically resemble the scleroderma occurring in human beings, can be experimentally produced in young rats by the injection of parathyroid extract, and therefore strongly suggest a relationship between scleroderma and parathyroid dysfunction.

In that particular form of scleroderma in which the Thibierge-Weissenbach syndrome is found, calcium concretions frequently occur in the skin. We³⁹ have compared sections of skin taken from normal areas and from involved areas on the same patient in the localized form of scleroderma. These studies showed a 20 to 30 per cent increase in calcium content in the sclerodermatous regions. Roentgenographic studies of the skin of these patients also show such differences in density as could be accounted for by calcium deposition.

In the classical examples of hyperparathyroidism the skeletal changes are considered the most characteristic manifestations. It is only logical that if scleroderma is to be viewed as a manifestation of hyperparathyroidism, these characteristic skeletal changes should be found in this condition as well. In one of our previous publications³⁹ we called attention to the fact that in many cases of scleroderma there is a diffuse decalcification, as revealed by roentgenographic studies, which is not only limited to the spongy portions of the bones but also involves the cortex. It is usually more pronounced in the extremities and is frequently localized in the hands and feet, especially the phalanges. Occasionally, we have observed cases in which the decalcification and rarefaction was so intense that the osseous structures of one or more phalanges could not be distinguished on the roentgenogram (Figs. 3 and 4). It must not be inferred from this that pronounced skeletal changes are always found in scleroderma, for we have observed many cases in which the roentgenographic studies revealed no osseous manifestations.

In some forms of scleroderma, however, characteristic skeletal changes are observed, clearly suggesting a disturbance in calcium metabolism and adding more prominence to the rôle played by the parathyroids.

In recapitulation, the rationale for the conception that the parathyroids (or rather hyperfunction of the parathyroids) are of pathogenic significance in scleroderma, and therefore parathyroidectomy is in-



Fig. 3.—Roentgenogram of hand of patient with generalized scleroderma. Note osteoporosis which is so pronounced in the terminal phalanges that they appear to have disappeared. Clinically the fingers were intact, and there was never any infection in them.

icated as a therapeutic procedure, is based upon the following facts and observations: Hypercalcemia is frequently found in certain forms of scleroderma. Cutaneous changes clinically and histologically resembling scleroderma have been experimentally produced by injections of parathyroid extract. Studies of the skin in certain forms of scleroderma show an abnormal increase of calcium content. Skeletal changes

are not infrequently encountered in scleroderma, demonstrating a disturbance in calcium metabolism and reflecting parathyroid dysfunction. In addition to this, the pronounced hypotonia and asthenia, frequently observed in patients with scleroderma, are also suggestive of calcium metabolic disturbances and hyperparathyroidism.

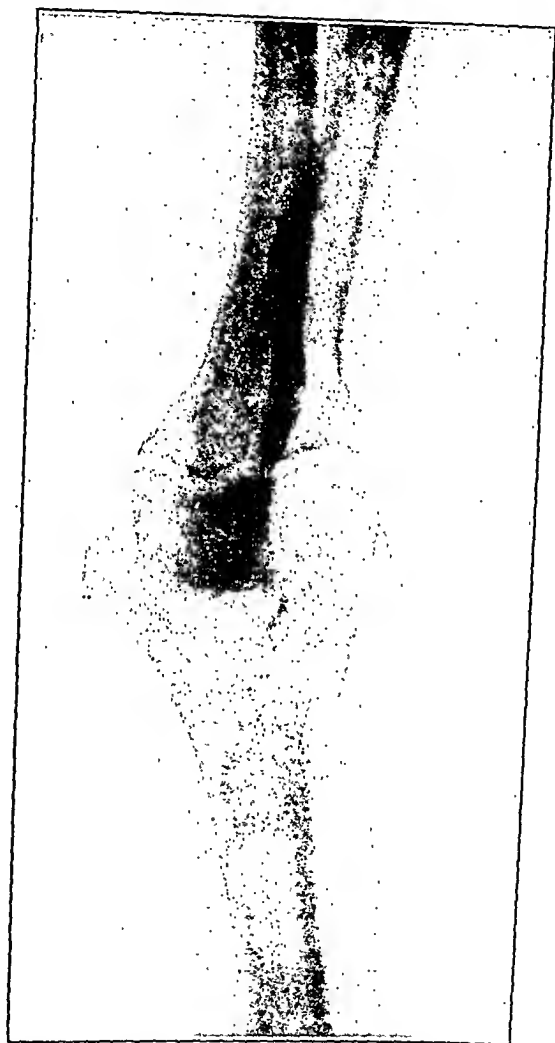


Fig. 4.—Roentgenogram of the humerus, radius, and ulna at the elbow joint of a patient with generalized scleroderma. The partial osteoporosis is quite evident.

CLINICAL CONSIDERATIONS OF PARATHYROIDECTOMY

Because these clinical and experimental observations seemed to indicate that in scleroderma there is a definite physiologic disturbance in the calcium metabolism, suggesting a hyperfunction of the para-

thyroids, it seemed to us that parathyroidectomy was not only justifiable but a logical therapeutic procedure. It was with this basic consideration that we¹⁰ performed our first operation of parathyroidectomy in January, 1931. As will be seen from a résumé of this observation (Case 21) given below, in spite of the fact that this patient had an advanced and generalized form of scleroderma, the operation was followed by a remarkable improvement. This encouraging result further justified the performance of parathyroidectomy. Several of these cases have been reported in detail elsewhere.¹¹ However, we are presenting a succinct account with follow-up reports of all the cases of scleroderma in which this procedure has been performed in this clinic.

It will be observed that the majority of these patients had a severe, generalized, and advanced form of scleroderma. Nevertheless of the 13 cases 5, 38.4 per cent, showed marked improvement, 7, 53.8 per cent, showed moderate improvement, and 1, 7.6 per cent, showed no improvement. Thus, of the total series definite improvement, to a greater or lesser degree, followed operation in over 90 per cent.

The one case showing no improvement deserves some comment (Case 15). This patient had Addison's disease in addition to an advanced scleroderma, and immediately following the operation there was an undeniable amelioration in the dermatologic manifestations. However, the patient lived only two months following the intervention. She probably succumbed to the Addison syndrome, and strictly speaking should not be considered as unimproved following parathyroidectomy. Thus, it can be said that actual improvement followed the operation in all of the cases.

It is a well-established fact that one of the most important criteria in the evaluation of a particular procedure is the length of time improvement is maintained following its application. In this series it will be noted that 6 patients have been observed from approximately two to five years after surgical intervention. All of these patients have not only maintained the improvement which immediately followed the operation, but have continued to improve. One of these (Case 14) was just recently examined, five years after operation, and it can be said that she has been completely relieved of all previous manifestations of the disease. One other patient (Case 17), when last observed two years following operation, also revealed no evidence of the previous sclerodermatous condition.

As will be observed from the cases listed, in several of the patients sympathectomy has been combined with parathyroidectomy. In previous publications one of us^{42, 43, 44} has discussed the indications for the combination of these two procedures in scleroderma. It may be stated that, in general, sympathectomy should be combined with para-

are not infrequently encountered in scleroderma, demonstrating a disturbance in calcium metabolism and reflecting parathyroid dysfunction. In addition to this, the pronounced hypotonia and asthenia, frequently observed in patients with scleroderma, are also suggestive of calcium metabolic disturbances and hyperparathyroidism.

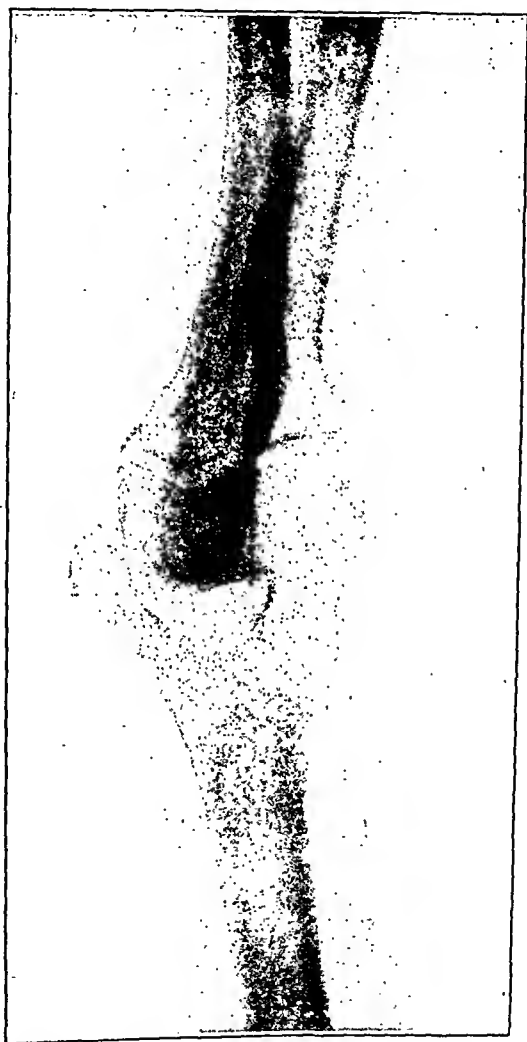


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Because these clinical and experimental observations seemed to indicate that in scleroderma there is a definite physiologic disturbance in the calcium metabolism, suggesting a hyperfunction of the para-

hospital she seemed considerably improved. She had no more joint pains; her temperature, which had previously been slightly elevated, was normal; her skin was much more flexible, and the finger joints could be moved with ease. Blood calcium dropped to 0.089. She was seen again in December, 1935, about two and one-half years after operation, and marked improvement was still present.

CASE 17.—A girl, eighteen years old. At the age of thirteen she began to complain of vasomotor disturbances in her fingers which resembled typical Raynaud's disease. At sixteen she developed sclerodermatous changes, involving her face, neck, and shoulders. Her skin was thick, indurated, edematous, and tense. Blood calcium was 0.102. On June 7, 1932, the right inferior thyroid artery was sectioned between ligatures. Parathyroids were not found. She seemed much improved immediately following operation. Her skin returned to normal, and the blood calcium was 0.089. Patient, when seen again about two years after operation, appeared completely cured.

CASE 18.—A woman, fifty-four years of age, had had vasomotor disturbances typical of Raynaud's disease for ten years. Simultaneously she developed sclerodermatous changes which on examination appeared pronounced and generalized. Her face was masklike and devoid of expression. Her mouth could be opened only slightly and speaking was very difficult. Hands were typically deformed and pigmentation was generalized. She also had digestive disturbances and involvement of the joints. Blood calcium was 0.104. On Sept. 10, 1934, operation was performed. Parathyroids were not found but both inferior thyroid arteries were sectioned between ligatures. She showed improvement on the day after operation. Her hands and feet were warmer and three weeks later she seemed considerably improved. Her mouth could be opened more easily and the skin of her face was more flexible. On March 21, 1935, resection on both sides of middle cervical sympathetic ganglions was done. When last examined in January, 1936, there was very little improvement over that previously stated.

CASE 19.—Woman, aged fifty-three years, had complained of vasomotor disturbances in her hands and feet, resembling atypical Raynaud's disease, for seven years. Almost simultaneously she noticed beginning sclerodermatous changes, which on admission were found to be generalized, with marked pigmentation on the upper extremities. Fingers were immobilized in semiflexion. Wrists, shoulder joints, and knees were almost completely immobilized. Opening the mouth was very difficult. Blood calcium was 0.124. An x-ray film showed marked osteoporotic changes in the hands. On Feb. 24, 1933, bilateral lumbar sympathectomy was performed and on March 11, 1933, right inferior parathyroidectomy (histologically verified). She was last observed in December, 1935. Her condition was much improved. Whereas previous to operation she was forced to remain in bed, she is now able to walk and get about without difficulty. Pain in the extremities has disappeared and also the pigmentation (except in the lower extremities). Her mouth could be opened with greater ease, and the skin of her face was more flexible. Also immobility of the fingers was less marked.

CASE 20.—Woman, forty-one years of age. For twelve years she had complained of vasomotor disturbances in her hands, characteristic of Raynaud's disease. About the same time she began to develop sclerodermatous changes. On examination, scleroderma was found to be markedly advanced, involving almost the entire body, with pigmentation and joint involvement. She was in constant pain and in poor general condition. Blood calcium was 0.076. X-ray examination revealed generalized osteoporotic changes, especially marked in the bones of the hands. On Aug. 30, 1933, a left lumbar sympathectomy was performed. Following this, the patient complained of less pain in her left leg. Right lumbar sympathectomy on Sept. 26, 1933, was followed by amelioration of the pain in the right leg. Movement of joints of the

thyroidectomy in those patients characterized by symmetrical lesions, especially of the extremities, and having typical vasomotor disturbances.

The technical considerations of parathyroidectomy have been discussed in detail by one of us⁴⁵ in a previous publication. Those who have had even the slightest experience with surgery of the parathyroids appreciate fully the technical difficulties that are encountered. Not infrequently it is impossible, even with meticulous dissection, to find these small glands. Under such circumstances we have found that a substitute procedure is the ligation and section of the inferior parathyroid arteries. It seems that this procedure, by diminishing the blood supply to the glands, suffices.

CASE 14.—Woman, aged sixty years. She began complaining, at the age of thirty-seven, of pain and a burning sensation in the skin over the right external malleolus. Skin in this region was dry, indurated, and had a cyanotic hue. For the past eighteen months similar disturbances developed in the left leg, and pain finally became so intense that she was forced to stop working. On examination advanced sclerodermatous changes were found on the legs, especially involving the dorsum of the feet, ankles, and the lower half of the legs. Her ankles were almost completely immobilized. Blood calcium 0.112. On March 27, 1931, we ligated and sectioned the right inferior thyroid artery. On the day following operation the patient seemed to be improved. Skin developed a more normal color. Blood calcium on April 1, 1931, was 0.087. When the patient was dismissed from the hospital ten days after operation, she seemed considerably improved. She had no more pain and could move her ankles with ease. When reexamined March 18, 1936, about five years after operation, she had no more pain, her skin was almost normal in color and flexibility, and there was no limitation in motion of the ankles. She appeared completely cured.

CASE 15.—Woman, aged thirty-four years. For three years she had complained of vasomotor disturbances in her hands. There were marked sclerodermatous changes of the face, neck, forearms, hands, and fingers. The rest of her body was also involved to a lesser degree, and the skin over the entire body had a bronzed discoloration similar to that in Addison's disease. She felt extremely fatigued and complained of constant pain in her knee and shoulder joints. Blood calcium 0.113. She had been treated for the past three weeks with adrenal extract in an attempt to relieve Addison's syndrome, and this phase of her condition seemed ameliorated, but the scleroderma appeared to be aggravated. On June 3, 1931, the right inferior parathyroid was found and removed. (Confirmed by histologic examination.) A few days following the operation she appeared considerably better. She was able to move her fingers more easily and no longer complained of pain. Blood calcium on July 3, 1931, was 0.089 and on July 10, 0.090. Two months later the patient returned to the hospital and was found to be much worse; she was in such a gravely ill state as not to justify any intervention. She rapidly became worse and died in three weeks. Autopsy not obtained.

CASE 16.—A woman, thirty-two years old, complained of vasomotor disturbances resembling Raynaud's disease in her hands and feet since childhood. For three years she has developed sclerodermatous changes which, on examination, involved particularly her hands and the lower half of her legs. Finger joints were partially immobilized. Blood calcium 0.112. On May 26, 1932, her right inferior parathyroid was found and removed. (Confirmed by histologic examination.) On the day after operation the discoloration of the skin disappeared, and when the patient was dismissed from the

generalized. The patient's face was like a mask. His fingers were stiff and like stone. He complained of marked pain in all joints. He had digestive disturbances and diarrhea. On Feb. 13, 1934, blood calcium was 0.095, and on May 20, 1934, it was 0.091. Over a three-day period he ingested 2.72 grams of calcium and excreted 3.55 grams. On Dec. 15, 1934, the urinary calcium was found to be 0.225 gram per liter and 0.222 gram during twenty-four hours. On May 28, 1935, the inferior parathyroids were removed (histologically confirmed). Blood calcium on June 4, 1935, was 0.084. Following operation, the skin condition showed considerable improvement. When seen again in January, 1936, the improvement in the skin was even better, but he still complained of joint pains.

CASE 25.—A man, fifty-five years of age. Sclerodermatous changes began about one year previously. On admission he had advanced scleroderma, involving almost the entire body, being especially marked on the face, back, and upper extremities. His hands were completely immobilized, with fingers in semiflexion. On Oct. 20, 1935, the blood calcium was 0.086; the urinary calcium was 0.162 per liter, and 0.287 per twenty-four hours. Calcium determinations of the skin revealed 0.139 gram per 1,000 grams (fresh), and 0.503 (ashes). On Nov. 29, 1935, both inferior parathyroids were removed (histologically confirmed). There was marked improvement following operation. To increase the improvement in the upper extremities resection of the inferior cervical sympathetic ganglions was performed on the left and right sides, Dec. 12 and 28, 1935, respectively. On dismissal from the hospital Jan. 9, 1936, the patient showed definite improvement in general. The skin was much more flexible and finger joints showed greater amplitude of motion. Blood calcium on Dec. 5, 1935, was 0.082. Calcium determinations of the skin were 0.199 gram (fresh) and 0.465 gram (ashes); water content 57.2 per cent. Similar determinations of the muscles gave 0.123 gram (fresh) and 0.491 gram (ashes).

CASE 26.—A woman, forty-three years old, had, for three years, complained of vasomotor disturbances in the fingers, similar to Raynaud's disease. Shortly after this she began to develop sclerodermatous changes, which upon admission were found to be generalized, being especially pronounced on the face, neck, and hands. With onset of scleroderma she began losing teeth which had previously been in good condition. She also complained of digestive disturbances and alternating constipation and diarrhea. X-ray examination revealed marked decalcification in the bones of the hands. Blood calcium was 0.086; urinary calcium was 0.088 gram per liter and 0.058 gram per twenty-four hours. Calcium determinations of the skin showed: 0.145 gram (fresh) and 0.412 gram (ashes). Water content 64.7 per cent. On Feb. 10, 1936, two inferior parathyroids were removed (histologically confirmed) and right cervical sympathectomy was performed, and on Feb. 27, 1936, she had a left cervical sympathectomy. Following operation, there was moderate improvement in the condition of the skin, especially in the face, neck, and thorax, but no improvement in the condition of the joints. Blood calcium 0.084. Patient was last examined April 3, 1936, at which time the finger joints were more mobile and the skin condition in general was much improved.

SUMMARY

1. The etiology and pathogenesis of scleroderma remain yet unknown and up to the present time nonsurgical treatment has been of little or no avail.
2. The rationale for the conception that the sympathetic apparatus is of pathogenic significance in certain forms of scleroderma and, therefore, sympathectomy is indicated as a therapeutic procedure, is discussed in detail. In this so-called Raynaud-scleroderma type of

legs was definitely improved. Right inferior cervical ganglionectomy on Feb. 26, 1934, was followed by similar improvement in the right upper extremity. April 24, 1934, a similar operation was performed on the left side. Oct. 1, 1934, two inferior parathyroids were removed (confirmed histologically). Three weeks later patient showed marked improvement in general. Pigmentation disappeared and she no longer complained of joint pains. She was able to move her joints to greater amplitude and more easily. The skin was much more flexible and her mouth could be opened easily. Although bedridden previous to operation, she is now able to get about easily and has gained weight.

CASE 21.—Woman, fifty-seven years of age. For the past twelve years she has complained of vasomotor disturbances resembling typical Raynaud's disease. About the same time she developed sclerodermatous changes which at the time of admission were very advanced and especially marked over the face, neck, hands, and feet. Fingers were completely immobilized in semiflexion. Blood calcium was 0.110. Jan. 15, 1931, left cervical sympathectomy was performed together with section between ligatures of the left inferior thyroid artery. There was considerable amelioration in the left upper extremity following this operation. On Jan. 23, 1931, resection of the right inferior cervical ganglion and removal of the right inferior parathyroid (histologically confirmed) were performed. Blood calcium on Jan. 26, 1931, was 0.082. Following operation, the patient showed similar improvement on the right side. Her skin began to have a more normal appearance and that on the face and neck became more flexible; she was also able to move her fingers with greater ease. She had no more pain except to a slight extent in her feet and legs. On Feb. 10, 1931, we performed a bilateral periarterial sympathectomy of the external iliacs. On dismissal from the hospital she had no more pain. When last heard from in April, 1931, the patient was still considerably improved.

CASE 22.—Woman, thirty-four years old. At nineteen years of age she began having vasomotor disturbances typical of Raynaud's disease. No long afterward she developed sclerodermatous changes involving the face, neck, and hands. Blood calcium was 0.115. On Sept. 17, 1931, resection of the right inferior cervical sympathetic ganglion was performed, followed on Sept. 26 by left cervical sympathectomy and removal of the left inferior parathyroid gland (histologically confirmed). Following operation the patient showed marked improvement. Blood calcium dropped to 0.090. When examined again in June, 1932, the skin on the face and neck had returned to normal, and that on the hands was much improved but there was still some cyanosis in the hands. On June 22, 1932, bilateral perihumeral sympathectomy was performed and following this, the hands became warm and pink. Last observed July 18, 1935, almost four years after operation. Skin of face and neck appeared normal. Mouth could be opened normally. Previous improvement was maintained.

CASE 23.—A woman, twenty-seven years of age, began to notice sclerodermatous changes one year previously, with some vasomotor disturbances in the hands. Scleroderma was especially marked on the face, neck, hands, and forearms. Her mouth could be opened only with difficulty, and movement of fingers was very limited. There was slight involvement over the ankles. Blood calcium was 0.110. On Nov. 14, 1931, the left inferior parathyroid was removed (histologically confirmed). Patient seemed much improved, skin appeared more flexible, and pain in the legs had disappeared. Blood calcium dropped to 0.094. On Nov. 26, 1931, resection of the right inferior cervical sympathetic ganglion was performed. Patient was seen again Jan. 23, 1932, and showed marked improvement. She had no more pain, her skin was more flexible with more normal hue, and her fingers had regained complete mobility.

CASE 24.—Man, forty-two years old. Sclerodermatous changes developed in past year and a half. At the time of admission scleroderma was very pronounced and

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syndrome histopathologic studies reveal definite vascular changes and clinical investigations show evidence of pathologic hypertonus of the arterioles.

3. Résumés of 13 cases of scleroderma in which we have performed sympathectomy are presented. Improvement to a greater or less degree followed operation in approximately two-thirds of the cases. One is forced to the conclusion that a disturbance in the equilibrium of the sympathetic apparatus is not the only or even the most significant factor in the pathogenesis of scleroderma.

4. The rationale for the conception that a chronic hyperfunction of the parathyroids is of pathogenic significance and, therefore, parathyroidectomy is indicated as a therapeutic procedure, is discussed in detail. Clinical and experimental investigations clearly demonstrate a definite disturbance in calcium metabolism, thus reflecting exaggerated physiologic function of the parathyroids.

5. Résumés of 13 cases of scleroderma in which we have performed parathyroidectomy are presented. On several of these patients sympathectomy was also performed. Improvement to a greater or less degree followed operation in over 90 per cent of the cases. Two of the patients, examined two and five years respectively after operation, could be considered as cured. All of the patients had rather severe and generalized forms of scleroderma. Only one patient was considered to have shown no improvement, although amelioration was observed immediately after operation, but the patient died two months later of the complicating Addison's disease.

6. In our experience parathyroidectomy is the procedure of choice in the treatment of scleroderma. It is unjustifiable to state definitely that scleroderma is caused by hyperparathyroidism. But clinical and experimental evidence supports the view that a chronic hyperparathyroidism does exist in scleroderma, and parathyroidectomy seems to ameliorate the condition. Sympathectomy may be combined with parathyroidectomy in those patients characterized by symmetrical lesions, especially of the extremities, and in those having typical vasomotor disturbances.

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THE SPHINCTER OF ODDI IN MAN AND CERTAIN REPRESENTATIVE MAMMALS*

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NOTWITHSTANDING the mixed aura of credulity and suspicion that surrounds what one surgical text has called "the rather mythical sphincter of Oddi," the experimental work of the last twenty-five years points unmistakably to the existence of an intrinsic musculature which under certain morbid conditions can produce biliary stasis. Although, at first, attention was focused upon the reaction of this muscle to cholecystectomy,¹⁻⁵ in recent years greater emphasis has been placed upon its dysfunction in the presence of an intact gallbladder—upon a dyskinesia of the biliary tract that may induce gallbladder distress or colic even in the absence of calculi or of inflammation.⁶⁻¹⁰

In view of these extensive studies, why is it that skepticism still exists regarding the sphincter of Oddi? The answer is twofold. In the first place it has been exceedingly difficult to separate its action from that of the duodenal muscle which surrounds it—a feat that has been rarely accomplished, experimentally. Second, on account of the small size, position, and complexity of the sphincter, it has been equally hard to demonstrate its independence, histologically. Even Nuboer,⁴ who has provided the only graded series of sections through the adult human sphincter, has confused intestinal tunics with the musculus proprius of the bile duct. Nor has such an imaginative diagram as that found in Cunningham's *Anatomy* (Fig. 915, 1928) made it any easier to comprehend. The matter has been still further complicated by the most amazing species differences—that factor which so long retarded our understanding of the functions of the gallbladder.

Believing, therefore, that some simpler anatomic approach to the problem was needed, the writer, some time ago, started a series of comparative studies on the embryologic development of the choledochal musculature, of which this paper represents a preliminary account.

DEFINITION OF THE SPHINCTER OF ODDI

According to Francis Glisson (1654), who first observed this "locking" mechanism, the sphincter consists of "ringlike fibers which occupy not only the opening [of the bile duct] itself but also the whole

*Presented at the Durham meeting of the American Association of Anatomists, April, 1936. The references to the human sphincter are based upon the studies of Schwegler and Boyden.¹⁸

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of individuals have an ampulla 2 mm. or less in length—a fact which has led these authors to conclude that regurgitation of bile into the pancreatic duct must be of rare occurrence.

In the dog,²¹ there is no ampulla, since even in the embryo the ducts open separately into the duodenum.

These illustrations suffice, perhaps, to show what varied conditions exist in one class of vertebrates and how different the sphincter must be in the four species. For convenience, the muscle will now be described, regionally.

THE MUSCULUS PROPRIUS AMPULLAE

In the opossum, the ampulla of Vater and its duct are clothed with a thick, double layer of smooth muscle (consisting of an outer circular and an inner longitudinal coat), which starts well above the junction

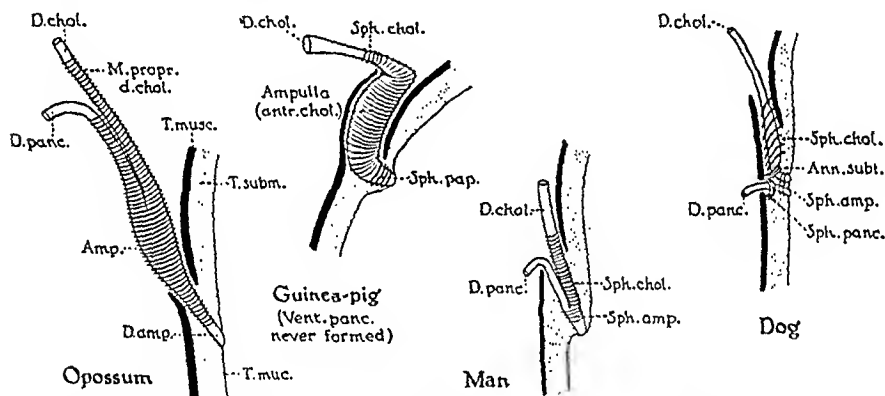


Fig. 1.—Posterior views of the pars intestinalis of the common bile duct in four mammalian species, based upon unpublished reconstructions of fetal stages. Heavy black lines: tunica muscularis of duodenum; transverse lines: circular fibers of musculus proprius of ducts and ampulla. (Orientation same as in Fig. 149b, Braus' Anat. d. Menschen, Vol. II, 1924.)

of the lumina of bile and pancreatic ducts and continues through the intestinal wall to a zone near the orifice of the ampullary duct. Its most striking and significant feature, as brought out by DuBois and Hunt,¹⁵ is the complete separation of its musculature from that of the duodenal wall throughout its intramural course. Wherever the two muscle layers approach each other a connective tissue layer intervenes. Even in the new embryonic preparations of these authors (which I have had the privilege of examining in advance of publication) the margins of the aperture in the intestinal muscle through which the ampulla passes, make little if any contribution to the sphincter of Oddi; i.e., embryonic and adult patterns are essentially alike. One cannot overestimate the importance of these observations. They show that in a primitive mammal the biliary musculature is independent of that of the intestine. Physiologically, the ampulla and its duct seem

oblique tract [through the intestinal wall]."¹² So also to Oddi¹² it is "a more or less pronounced bed of circular fibers encircling the choledochal canal—which one is able to consider as almost completely independent, if one excepts some slender loops which lose themselves between the fibers proper of the intestine." Incidentally, Oddi's name has been applied to it not because he was the first to examine it microscopically—that distinction belongs to the American anatomist Simon H. Gage¹³—but because he demonstrated it in a variety of animals and because he was the first to measure its resistance, to show that removal of the gallbladder caused marked dilatation of the bile ducts, and to postulate that dysfunction of this occluding apparatus might explain certain morbid affections of the biliary tract. With the more complete information now at our disposal it has come to be realized that the longitudinal fibers of the sphincter may be as important as the circular fibers—at least, in some species—hence the concept that the sphincter of Oddi is an ejecting as well as an occluding mechanism.^{6, 14} It is necessary, therefore, to define it as the entire *museulus proprius* of the terminal portion of the bile channel and of the associated pancreatic duct (of Wirsung), if the latter is present.

THE RETROGRESSION OF THE AMPULLA

Fig. 1 presents a group of diagrams showing how certain mammals may be arranged in a series to illustrate the progressive involution of the ampulla of Vater.

In the opossum, according to DuBois and Hunt,¹⁵ the terminal apparatus consists of a duct of the ampulla (*D. amp.*), coursing obliquely through the intestinal wall, of an ampulla itself (*Amp.*), which lies wholly outside the intestine, and of such distal portions of the two ducts as are enclosed in a common musculature.

In the guinea pig,^{16, 17} most of the ampulla has been taken into the intestinal wall, but it lies superficially, bulging out at the level of the intestinal muscle (Figs. 1-4). Its duct empties at right angles to the ampulla (Fig. 2). The duct of Wirsung, which by analogy with other rodents should join the bile duct outside the intestinal wall, never appears at any stage. Westphal⁶ compared the ampulla to the pyloric antrum of the stomach because it undergoes peristalsis. His other name for it (*portio duodenalis*), however, is misleading, for the papillary portion is also duodenal.

In man,^{18, 19} the confluence of bile and pancreatic ducts starts outside the intestine, but in the course of development the zone of junction becomes drawn into the wall so that in most adults the ampulla is a vestigial structure. According to Mann and Giordano,²⁰ 76 per cent

⁶For an account of this region as viewed by the older anatomists (Vesalius, Fallopius, Gilsen, Blanchi, Vater, Haller, Santorini, etc.), see Boyden.¹¹

when the musculus proprins develops, it blends with the intestinal tunics (cf. Figs. 2-4). Undoubtedly, also, its presence there, from the beginning, has modified the growth of the intestinal muscle. This blending of layers, however, does not occur in such animals as the cat where the ampulla lies in the submucosa and pancreatic and bile ducts occupy the level of the window. In such species the intestinal muscle may enter into complicated relationship with the two ducts, but the musculus proprins can be differentiated as a separate layer. The guinea pig, therefore, presents the most intimate union between biliary and intestinal musculature.

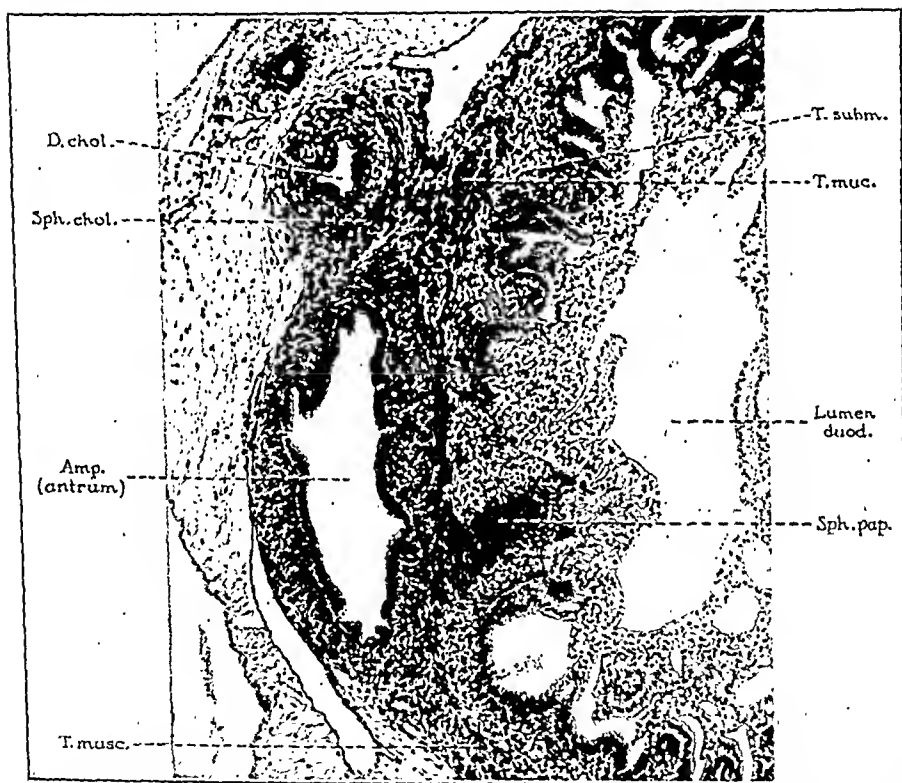


Fig. 3.—Photomicrograph of the same duodenum as that shown in Fig. 2, seven sections lower down (X90). Note sphincter around common bile duct (*Sph. chol.*) and tangential section of sphincter around the duct of the ampulla (*Sph. pap.*). The embryo is too young for the layers of muscle around the ampulla to be fully differentiated but longitudinal fibers can be seen leaving the mucosal side of the transversely cut intestinal muscle layer (*T. musc.*). (Cf. Fig. 1, guinea pig.)

Nevertheless, Higgins¹⁶ has noted that while peristalsis of the duodenum may affect the ampulla, active pulsations of the pouch can be observed in the absence of intestinal peristalsis. Furthermore, DuBois and Kistler²⁴ have shown that faradic stimulation of the antrum induces marked contraction of the gallbladder and that this effect disappears when the bile duct is severed; from these facts they infer the existence of a direct nervous pathway from ampulla to gallbladder.

to be primarily a mechanism for ejaculating bile through the intestinal wall (see authors' description of peristaltic waves^{15, 22}) since the gall-bladder has a weak musculature and an extremely narrow outlet into the cystic duct.*

In the guinea pig the intrinsic muscle of the ampulla (or antrum) is so blended with the circular muscle of the intestine that in the adult the two layers cannot be differentiated except at the edges or at the two ends of the ampulla. The probable explanation for this is that in the embryo the antrum remains at the level of the intestinal musculature, lying athwart the window in the tunica muscularis, so that

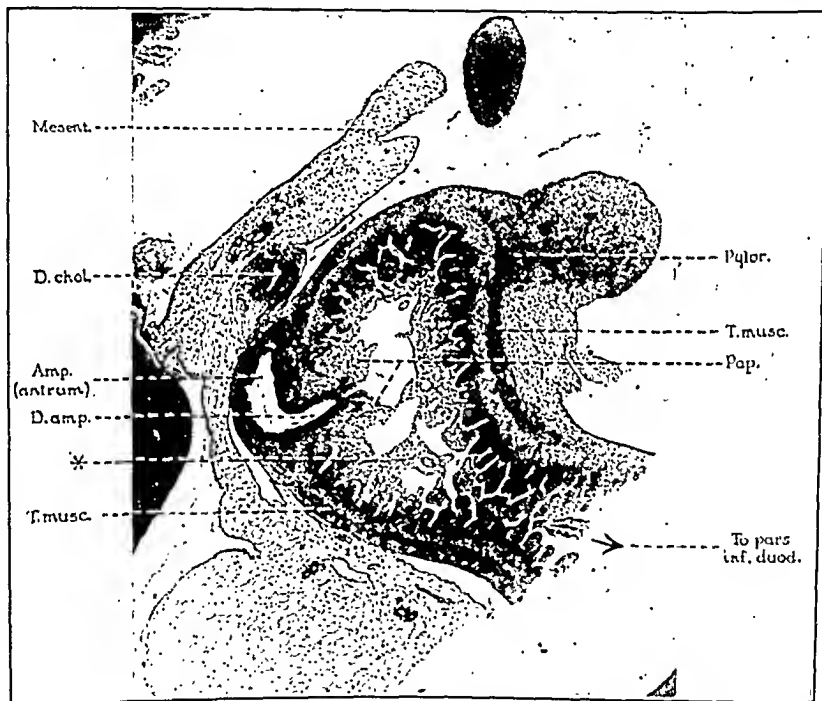


Fig. 2.—Low power photomicrograph of the first part of the duodenum in a 42 mm. guinea pig embryo ($\times 37$). Note common bile duct (*D. chol.*) in duodenohepatic ligament (*Mesent.*) and subdivision of the ampulla of Vater into an ampulla proper (the antrum of Westphal) and a duct of the ampulla (*D. amp.*), lying in the papilla (*Pap.*). Since this is an oblique section, the circular layer of the duodenum (*T. musc.*) is cut somewhat transversely. *The vestige of a vacuolated epithelium which completely filled the lumen of the intestine in earlier stages. The establishment of an intestinal lumen is a much slower process in the guinea pig than in the human embryo. For lower levels in the same specimen, see FIGS. 3 and 4.

*Apparently, however, the expelling mechanism of the opossum represents but a vestige of that which exists in fishes, for Higgins²³ has shown that in the common bullhead, peristaltic waves begin in the fundus of the gallbladder and extend all the way down the biliary tract into the duodenum. Furthermore, in its course through the intestinal wall, the somewhat thickened muscle of the bile duct is separated from the muscle of the intestine by a wide connective tissue layer (Fig. 9, loc. cit.). Since the intramural coat is merely a continuation of that around the extramural portion of the duct, Higgins raises the question as to whether it should be designated "sphincter of Oddi." I would reply that very likely this purely biliary muscle represents the first stage in the differentiation of the sphincter and that Dr. Higgins' important observations have provided the first clue to the phylogenetic origin of a structure which may have arisen as a compensation for loss of peristalsis in the upper regions of the biliary tract.

when the musculus proprius develops, it blends with the intestinal tunics (cf. Figs. 2-4). Undoubtedly, also, its presence there, from the beginning, has modified the growth of the intestinal muscle. This blending of layers, however, does not occur in such animals as the cat where the ampulla lies in the submucosa and pancreatic and bile ducts occupy the level of the window. In such species the intestinal muscle may enter into complicated relationship with the two ducts, but the musculus proprius can be differentiated as a separate layer. The guinea pig, therefore, presents the most intimate union between biliary and intestinal musculature.

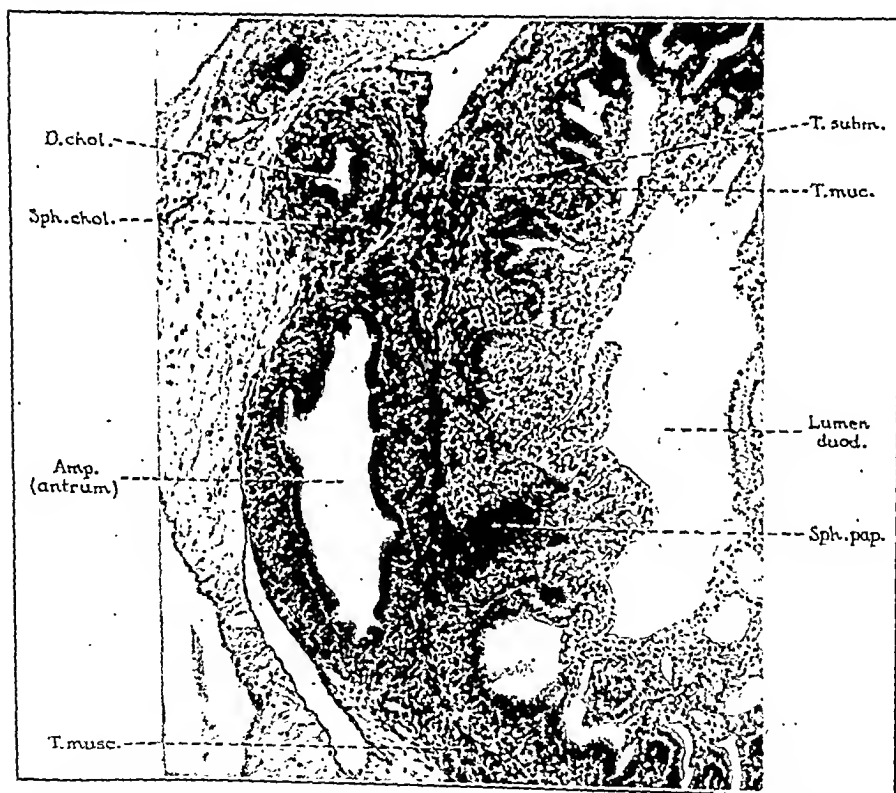


Fig. 3.—Photomicrograph of the same duodenum as that shown in Fig. 2, seven sections lower down ($\times 90$). Note sphincter around common bile duct (*Sph. chol.*) and tangential section of sphincter around the duct of the ampulla (*Sph. pap.*). The embryo is too young for the layers of muscle around the ampulla to be fully differentiated but longitudinal fibers can be seen leaving the mucosal side of the transversely cut intestinal muscle layer (*T. musc.*). (Cf. Fig. 1, guinea pig.)

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Finally, mention must be made of the *musculus proprius* of the *duct* of the ampulla to which Westphal⁶ has given the name *sphincter papillae* (cf. Figs. 1 and 3). He compares this to the pyloric sphincter and likens the ampulla to the pyloric antrum of the stomach, finding that the two sphincters are excited by the sympathetic system and that the two antra are caused to undergo peristalsis or even spastic contraction, by the vagus nerve.

In man, the muscle of the ampulla is a relatively weak layer, some distance removed from the intestinal window, and consists of lateral

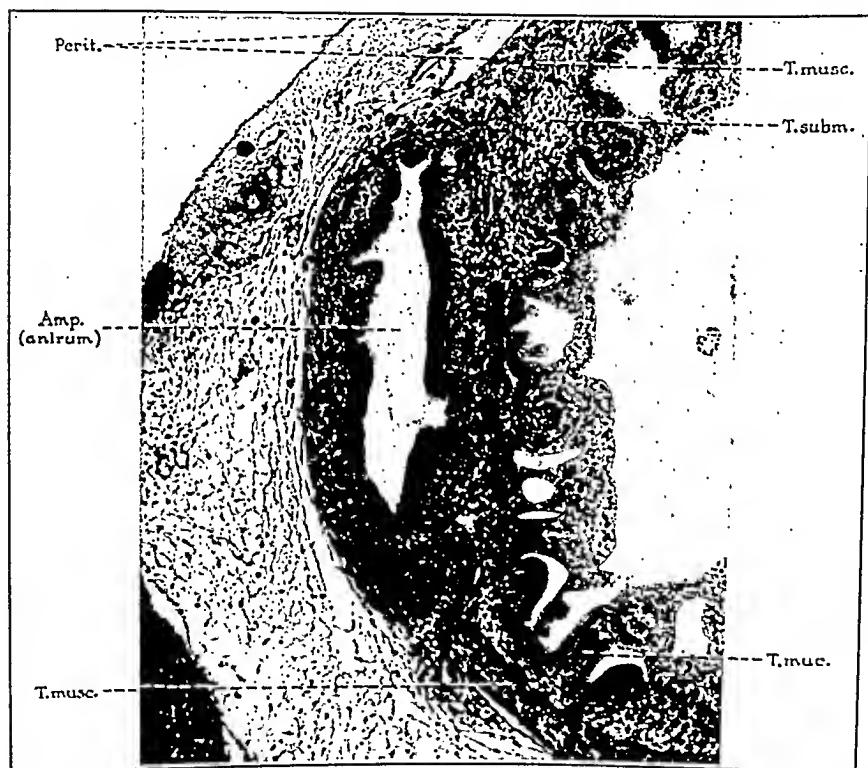


FIG. 4.—Photomicrograph of the same duodenum twenty sections below the level shown in FIG. 3 ($\times 90$). This shows the ampulla cut obliquely lengthwise and bulging from the intestinal wall into the mesentery, below the level at which it has been joined by the common bile duct.

bundles of longitudinal fibers overlying an inner circular layer (Fig. 5). No differentiation of this sheath into ampullary zone and sphincter papillae is demonstrable; nor do these layers seem strong enough or complete enough to provide a mechanism for peristalsis. It is believed, therefore, that the longitudinal fibers act in shortening the ampulla and that the circular fibers are chiefly effective in regulating the flow of pancreatic juice (described later).

In the dog, there is no ampulla of Vater and therefore no *musculus proprius ampullae*, unless the few delicate terminal rings that encircle both bile and pancreatic ducts just before they empty into the duodenum (Figs. 1 and 6) may be considered as such.

THE SPHINCTER CHOLEDOCHUS

In the opossum, the bile and pancreatic ducts, throughout the zone in which they run parallel to each other, are enveloped by a common sheath of intrinsic muscle which consists of well-developed outer circular and inner longitudinal layers (Fig. 1). This sheath is an upward extension of the ampullary musculature. In addition, the bile duct itself, above the point where it comes in contact with the pancreatic duct, has a double sheath for a short distance—the *musculus proprius ductus choledochi*. Its thin, outer, circular layer might be called a potential sphincter *choledochus*, since increase in tone would compress this segment of the duct, but DuBois and Hunt have never seen it contract independently of peristalsis.

In the guinea pig, however, there is a most powerful sphincter at this point. It has been observed in the living both by Higgins¹⁶ and by Burget and Brocklehurst.¹⁷ As peristaltic waves pass down over the bile duct onto the antrum, this sphincter contracts to prevent regurgitation of bile toward the liver.

In man there is a corresponding *musculus proprius* of the bile duct which begins just outside the intestinal window and extends to the ampulla (Fig. 1). Circular fibers predominate throughout, and these reach their greatest thickness near the ampulla. They are the “IR” and upper “S” fibers of Hendrickson.²⁵ This zone Dr. Schwegler and I have named the *sphincter choledochus*, and we consider it the most important part of the human sphincter of Oddi. A transverse section of it, in a seven months’ fetus, is shown in Fig. 5. Our embryologic studies indicate that it is entirely independent of the intestinal musculature, arising in situ from mesenchyma, like the *musculus proprius* of the ureter. Apparently it is the only zone capable of retaining the column of bile. Its importance has also been stressed by Matsuno,²⁶ who considered this band thick enough to produce biliary stasis. Incidentally, Nuboer⁴ has published sections showing the hypertrophy of this zone in an eighty-three-year-old patient in whom the gallbladder had been sidetracked by cholelithiasis. On the physiologic side Ivy, Voegtlin, and Greengard²⁷ have provided striking evidence that the column of bile can be held in the presence of an abundant flow of pancreatic juice. Having injected a human subject intravenously with 300 dog doses of secretion and 10 dog doses of cholecystokinin, they aspirated 162.5 c.c. of pancreatic fluid in forty-nine minutes. But this flow was

accompanied by typical gallbladder distress, which increased steadily until the pain was unbearable. At the end of forty-nine minutes a concentrated solution of magnesium sulphate was given by tube. In two minutes the distress disappeared and in seven minutes typical gallbladder bile was aspirated, showing that the salt had relaxed the sphincter that was holding the column of bile while the pancreatic juice was flowing.

In the dog²¹ almost the entire intramural course of the bile duct is encircled by scattered loops of intrinsic muscle. The lowest of these

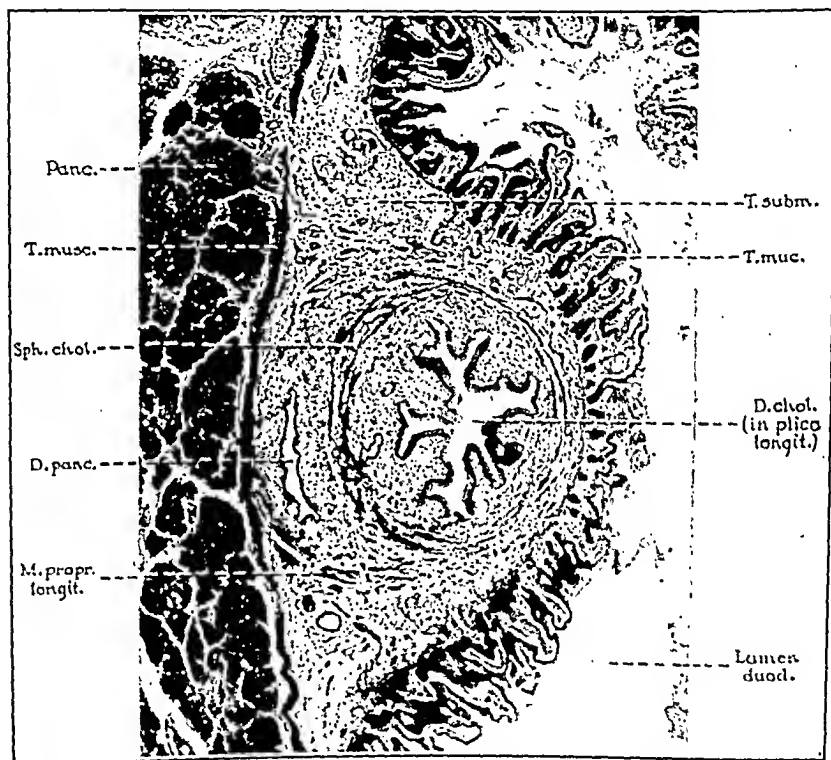


Fig. 5.—Photomicrograph of transverse section of pars intestinalis of common bile duct in a seven months' human fetus (from the studies of Schwegler and Boyden). (X31.) Note that the bile duct in its transit through the submucosa is surrounded by a thick ring of smooth muscle (*Sph. chol.*) which is some distance removed from the muscle of the intestine (*T. musc.*). No muscle ring surrounds the pancreatic duct (*D. panc.*), but there are longitudinal fibers (*M. propr. longit.*) which correspond to the "H," "K," and "X" fibers of Hendrickson (1898). This section lies a short distance above the level where bile and pancreatic ducts unite to form the ampulla of Vater (Fig. 1).

loops is thicker and more isolated than the rest and may be called the subterminal portion of the sphincter choledochus or the subterminal ring (annulus subterminalis; Figs. 1 and 6). Judging from the experiments of Lueth²² it plays an important rôle in retaining the bile. This author noted that when a cannula was advanced through the

intramural portion of the bile duct, the pressure fell in steps, and the distal zone bulged before the orifice opened, thus implying muscular compression near the end of the duct.

THE SPHINCTER PANCREATICUS

This is the least developed of all the intrinsic musculature under discussion. In the opossum it is barely suggested by tenuous strands (not shown in Fig. 1), which partially encircle the pancreatic duct in

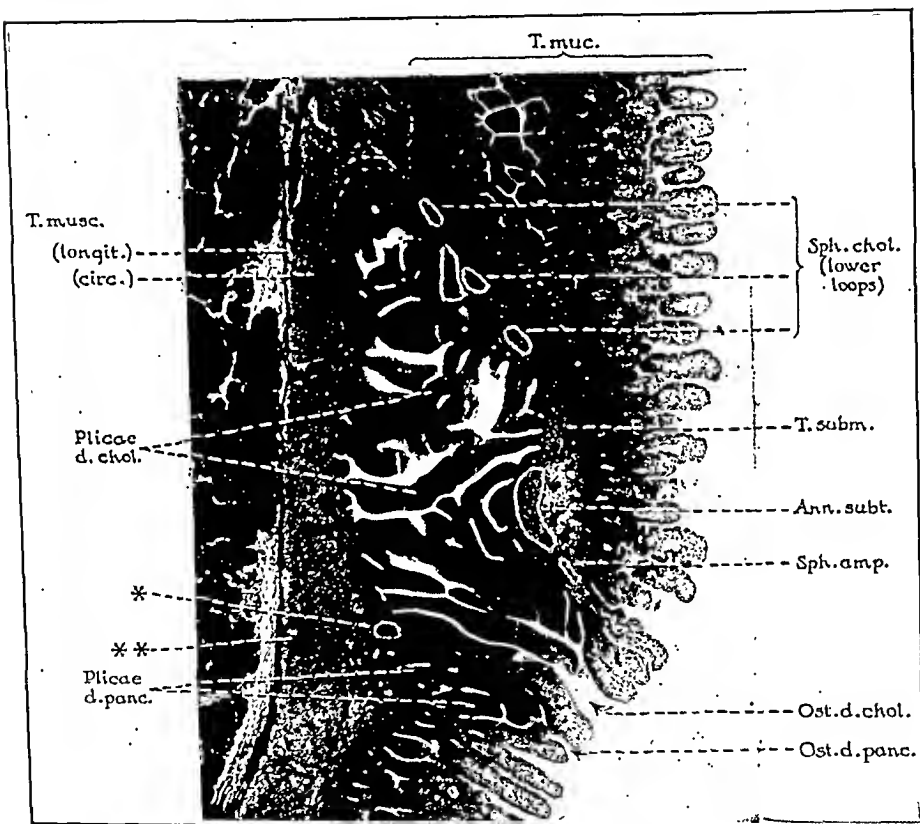


Fig. 6.—Photomicrograph of lower third of intramural course of bile duct in a newborn puppy, cut almost longitudinally (X37). In this section the lower loops of the sphincter choledochus (Fig. 1, dog) are cut transversely, and their margins have been outlined in white, since unfortunately the azocarmine stain which separates muscle from connective tissue so clearly does not photograph well. The lowest of these loops around the bile duct is the subterminal ring (*Ann. subt.*). Still nearer the lumen of the intestine and surrounding the orifices of both the duct of Wirsung (*Ost. d. panc.*) and the bile duct (*Ost. d. chol.*) is a vestige of the sphincter ampullae (*Sph. amp.*); *, portion of intrinsic muscle common to both the pancreatic and the subterminal sphincter (Fig. 1, dog); **, point at which the pancreatic duct will penetrate the circular muscle layer of the duodenum.

the region where the bile and pancreatic ducts first approach each other. Obviously, compression of the pancreatic duct is accomplished primarily through the layer of circular muscle which is common to both bile and pancreatic ducts. Apparently the same holds true in

accompanied by typical gallbladder distress, which increased steadily until the pain was unbearable. At the end of forty-nine minutes a concentrated solution of magnesium sulphate was given by tube. In two minutes the distress disappeared and in seven minutes typical gallbladder bile was aspirated, showing that the salt had relaxed the sphincter that was holding the column of bile while the pancreatic juice was flowing.

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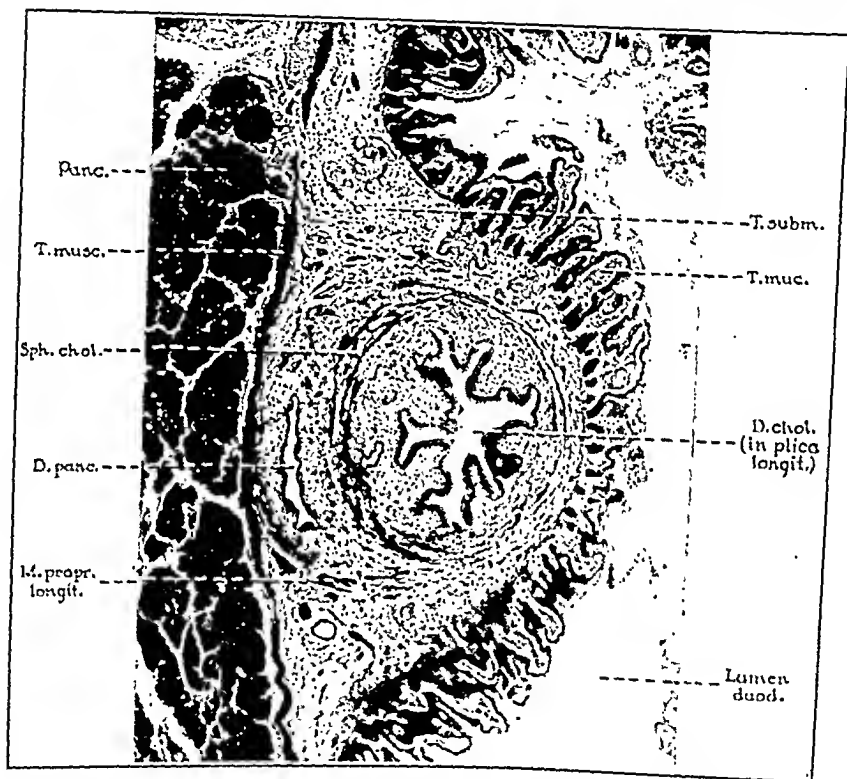


Fig. 5.—Photomicrograph of transverse section of pars intestinalls of common bile duct in a seven-months' human fetus (from the studies of Schwegler and Boyden). (X31.) Note that the bile duct in its transit through the submucosa is surrounded by a thick ring of smooth muscle (*Sph. chol.*) which is some distance removed from the muscle of the intestine (*T. musc.*). No muscle ring surrounds the pancreatic duct (*D. panc.*), but there are longitudinal fibers (*M. propr. longit.*) which correspond to the "H." "K." and "X" fibers of Hendrickson (1898). This section lies a short distance above the level where bile and pancreatic ducts unite to form the ampulla of Vater (Fig. 1).

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for only a few minutes, as pointed out by McMaster and Elman),³¹ and that therefore the gallbladder of this species is sluggish and rarely evacuates itself completely. Physiologic confirmation of this is to be found in the experiments of Sandblom, Voegtlin and Ivy.³² Employing dogs in which devices for securing simultaneous records of pressure changes in the duodenum and common duct had been installed, these authors found that intravenous injections of cholecystokin in increased duodenal tone and motility in 87 per cent of cases—although in the few instances in which the action of the drug on the sphincter of Oddi was not masked the sphincter was relaxed by the drug—thus emphasizing the obstructive effect of duodenal tone and motility in the dog.

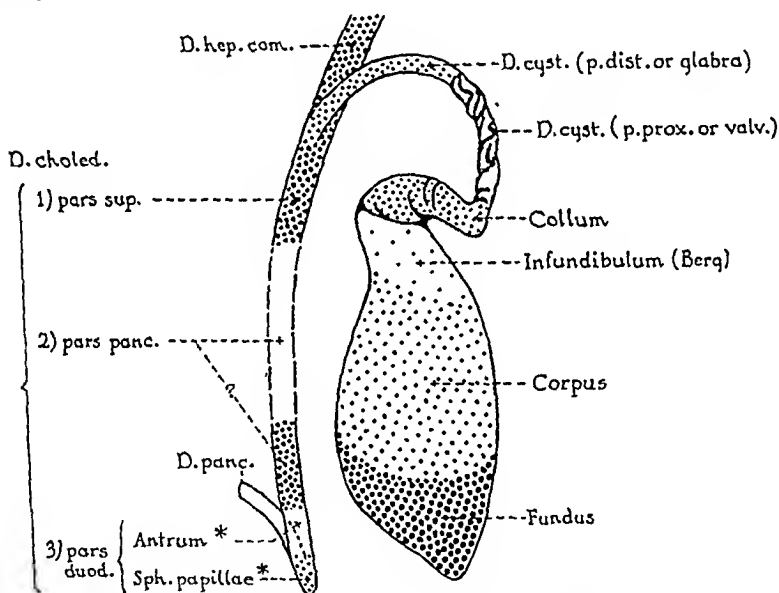


Fig. 7.—Aschoff's diagram of the extrahepatic bile passages in man (posterior view), to which has been added the ductus pancreaticus. (From Arch. f. klin. Chir. 126: 233, 1923.) This diagram is based largely on Charpy's account of the biliary tract in Poirier and Charpy's *Traité d'Anatomie Humaine*, 1901. *Westphal's names for upper and lower segments of the pars intestinalis in the guinea pig and rabbit. In man these portions of the musculus proprius should be called respectively, the sphincter choledochus and the sphincter ampullae.

SUMMARY

In conclusion, it may be noted that comparative embryologic studies have demonstrated that in the opossum, guinea pig, dog, and man, the pars intestinalis of the bile channel (and its associated duct of Wirsung, if present) is ensheathed in a two-layered musculus proprius which can be designated, legitimately, the sphincter of Oddi. The four species differ markedly in the degree to which different segments of the sheath are developed or suppressed, and in the relationship they bear to the duodenal muscle through which the bile duct enters the

man, for Schwegler and I have found no muscle fibers which completely encircle the pancreatic duct in the human fetus (see Fig. 5).

In the dog, however, where the duct of Wirsung empties separately into the duodenum, there is a ring of muscle which tends to form a figure eight with the subterminal portion of the sphincter choledochus (Figs. 1 and 6). This has previously been noted by Hendrickson. It may be considered a true sphincter pancreatens. For this reason we cannot follow Hendrickson in homologizing it with the fibers that constitute the sphincter choledochus.

DISCUSSION

Obviously, in this short article, it has been impossible to present any detailed description of these four species—a task which necessarily has been left for subsequent publications; rather, the object has been to give a general picture of the sphincter and to provide an anatomic foundation for analyzing its behavior in different species. To suggest how much such information is needed one has only to turn to Asehoff's much publicized diagram of the human biliary tract (Fig. 7) which, incidentally, is the best available. Here we see the terminal portion of the bile channel divided into two successive zones on the basis of Westphal's experimental study of the guinea pig and rabbit. The upper segment which represents the zone of the bile duct and its sphincter is labelled "antrum," yet the "antrum" of the guinea pig is the ampulla of Vater. The lower segment (the zone of the ampulla) is called "sphincter papillae," i.e., the muscle which in the guinea pig surrounds the *duct* of the ampulla. Whether these two regions in the guinea pig and man react to the same stimuli remains to be proved, but in any case they cannot logically be given the same name.

A second matter with which it has been impossible to deal, in the limits of this paper, is the disposition of intestinal muscle around the bile ducts. In general, however, the species differences in the pattern of this muscle are as marked as those in the intrinsic musculature. Two points only will be mentioned. In man, the window in the duodenal muscle, through which bile and pancreatic ducts enter the intestine, is of such shape and size that duodenal peristalsis exerts a minimal effect on the flow of bile. This may afford one explanation for the fact that in man two-thirds to three-quarters of the contents of the gallbladder are emptied within the first forty minutes after a meal of egg yolk.^{29, 30} By contrast the duodenal window of the dog has the shape of a funnel which envelops the first two-fifths of the intramural course of the bile duct. This may account for the fact that the phases of emptying in the dog are short and intermittent (lasting

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intestinal wall. The human sphincter has three marked anatomic characteristics: (1) its relative freedom from intestinal interference, due to the configuration of the window in the duodenal muscle through which it passes; (2) the retrogression of its ampullary segment; and (3) the development of a special constricting mechanism (the sphincter choledochus) just above the point where the bile duct joins the ampulla of Vater. Anatomically, this zone of intrinsic muscle would seem to be entirely adequate to sustain the column of bile and so to cause the gallbladder to fill during the interval between meals. If such be its normal function, it is not difficult to believe that hypertrophy or overstimulation of so strategically placed sphincter would result in biliary stasis and the production of right hypochondrial distress.

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THE FUNCTION OF THE "VALVES" OF HEISTER

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INTRODUCTION

ALTHOUGH the "valves"* in the cystic duct were well described and illustrated by Heister in his textbook,¹ he had difficulty in convincing others that these folds actually existed (Fig. 1). Subsequent observers, however, confirmed his findings and added much speculation concerning their function. They have been studied from many points of view, and considerable information concerning their anatomy, embryology, physiology, and pathology has been recorded.

On the basis of this work, various views of the function of the "valves" of Heister have been expressed. Some have suggested that their function is to impede the inflow of bile into the gallbladder;² while others have suggested that they impede³ or prevent⁴ the outflow of bile from the gallbladder. Keith⁵ has suggested that they prevent collapse by providing support to the walls of the duct. They have been viewed as baffle plates⁶ to secure a slow passage of viscous bile from the bladder without opposing the flow of thin hepatic bile into the gallbladder. Studies have been made on the pressure required to force fluid through the cystic duct in either direction. Lohner⁷ observed that less pressure is required to cause fluid to flow into the gallbladder than out of it. Mentzer⁸ concluded that the "valves" of Heister check the rapid passage of fluid into or out of the gallbladder. Johnson and Brown⁹ found no real impediment to the passage of fluid into or out of the gallbladder when the pressures found normally in the gallbladder were used. At lower pressures (8 cm. of water or below), a lag in the equalization of pressure between the gallbladder and the common duct was observed. This was attributed to the size of the ducts or to a "suction" action collapsing the ducts. The same authors also observed that the pressures between the duct and gallbladder equalized almost instantly and tended to do so even at low pressures. This held true when the pressure was varied on either side of the cystic duct.

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*The term "valves," referring to the folds in the cystic duct described by Heister, is retained for its historical interest. The folds, in fact, are not valves but are referred to as such in the same sense that the projections into the lumen of the small intestine are called "valvulae conniventes."

Thus, while many suggestions have been offered, the question of the function of the "valves" themselves still remains unanswered. If they are not a factor in regulating the flow of bile into or out of the gallbladder, the variations of rate of flow under varying pressure changes noted by Lohner, and Johnson and Brown require an explanation. The suggestion of Keith that they prevent collapse of the cystic duct is interesting, but further study seems indicated before it can be accepted.

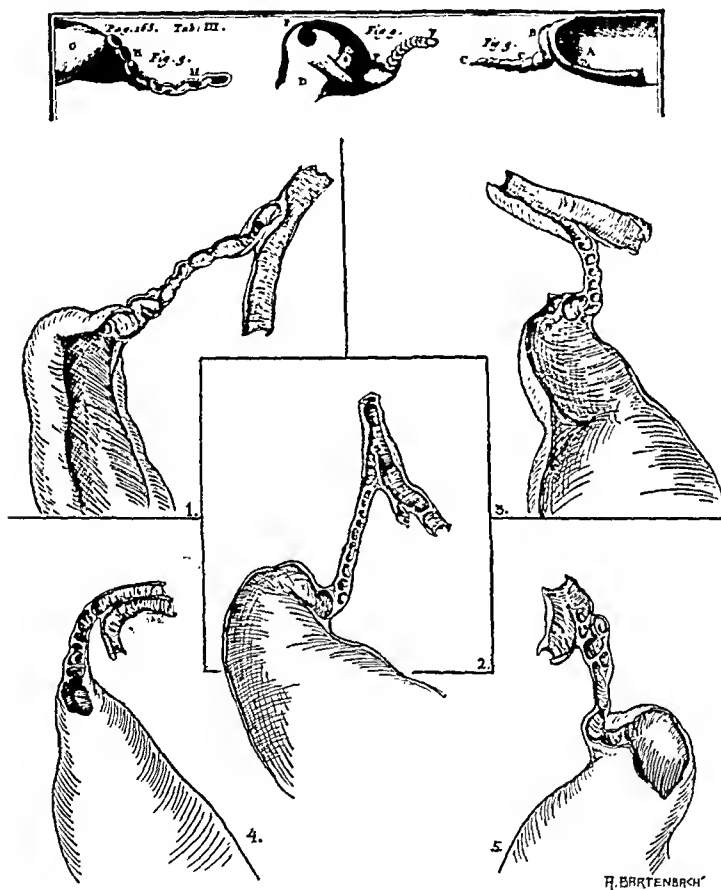


Fig. 1.—The "valves" of Heister.

ANATOMY

The "valves" of Heister are located in the neck and duct of the gallbladder. The anatomical divisions of the gallbladder are illustrated in Fig. 2.

The neck is defined¹⁰ as that portion between the first "valve" of Heister and the beginning of the cystic duct. This portion is usually demarcated proximally by a bend which appears between the infundibulum and neck, and distally by a bend between the neck and

cystic duct. The neck is usually fixed to the infundibulum rather loosely by areolar tissue surrounded by a fold of peritoneum. It is difficult, however, to separate the neck from the infundibulum when the cystic artery is intact, as the latter crosses both of these portions of the gallbladder and fixes them to each other. The neck varies considerably in size and shape and in many instances is not well defined.

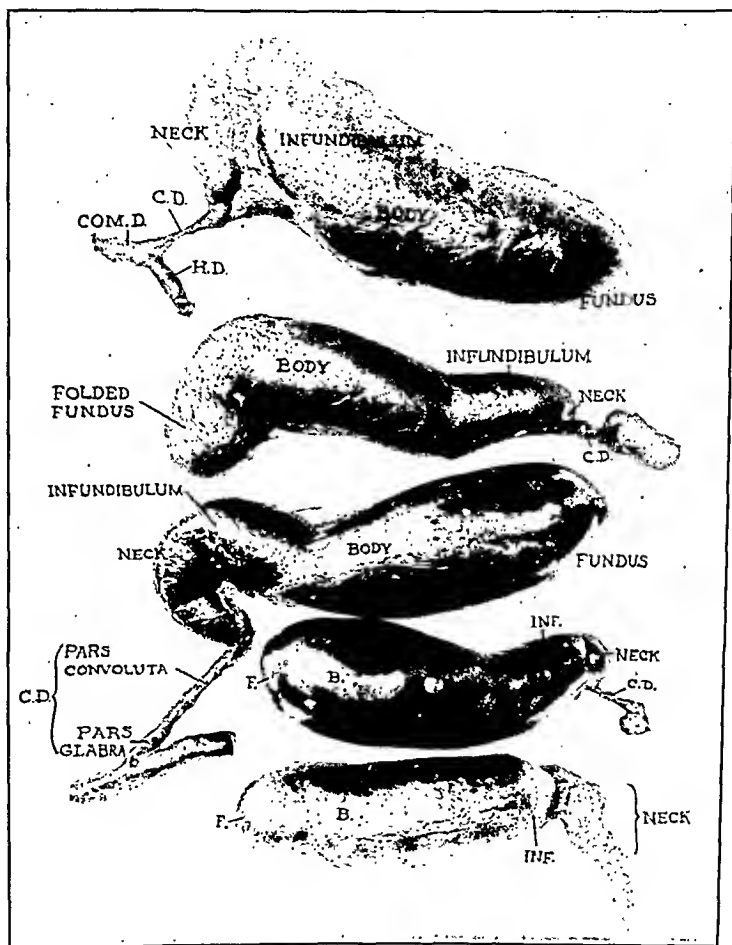


Fig. 2.—Anatomical divisions of the gallbladder.

The neck may continue imperceptibly into the cystic duct without a distal demarcation. It may be limited at either end by a single valve, or it may have a well-defined spiral fold extending the full length of its lumen. In some instances the first "valve of Heister" does not appear to be an independent leaflet projecting into the lumen of the gallbladder (Fig. 3A). We found that it may be made to disappear by removing all areolar tissue connections between the infundibulum

and neck and by then straightening the organ. This is similar to the fold that appears in the "folded fundus"^{11, 12} (Fig. 3B), and the origin may be identical.

The cystic duct varies in length, diameter, shape, configuration, internal architecture, and relation to surrounding structures (Fig. 4). The mucous membrane surface in many instances is divided into two distinct portions—the proximal portion with projections ("valves") called the *pars convoluta* and a distal portion without projections called the *pars glabra*. When the cystic duct is fully distended by air or water, it is found that the caliber of the *pars convoluta* is usually less than that of the *pars glabra* (Fig. 5).

At the junction of the cystic and the common hepatic ducts, a leaf-like fold is present. This projects toward the distal portion of the

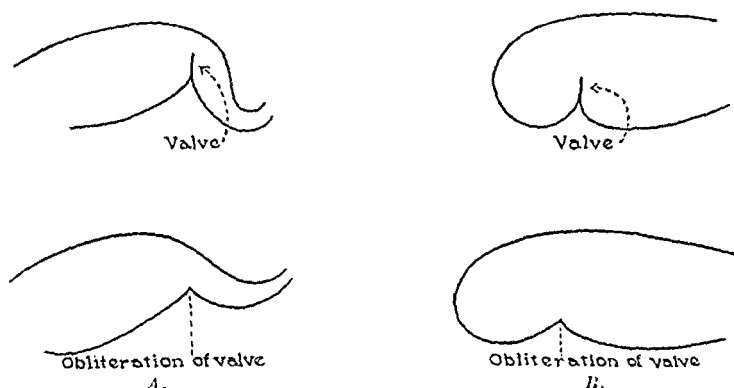


Fig. 3.—Leaflike projections in neck and fundus of gallbladder.

common duct, and it is likely that it acts as a wing dam deflecting the flow of bile away from the opening of the cystic duct (Fig. 6). If obstruction should occur, however, in the common duct distal to the entrance of the cystic duct, as occurs with the contraction of the sphincter of Oddi, or increase in tone of the duodenal musculature, bile would then back up into the cystic duct and enter the gallbladder. Thus, on the basis of anatomical structure, the filling of the gallbladder is dependent on an increase in pressure in the common duct due to closure of the outlet of the latter.

The adherence of the terminal part of the cystic duct to the common hepatic duct is of surgical importance. Numerous cases have been reported in which the latter was injured during operation or mistaken for the cystic duct and ligatured. These accidents are most likely to occur when the gallbladder is distended and the liver is in normal position, because the neck projects medially upward between the layers of the hepatoduodenal ligament and lies in contact with the common hepatic duct, the entire cystic duct being adherent to the latter.

Practically all forms of liver displacement tend to straighten out the cystic duct, but marked ptosis may produce a very acute bend in the cystic duct near its junction with the common hepatic duct, thus favoring obstruction.

Adhesions may fix the gallbladder to adjacent viscera, or by traction prevent the outward displacement of the gallbladder, or produce

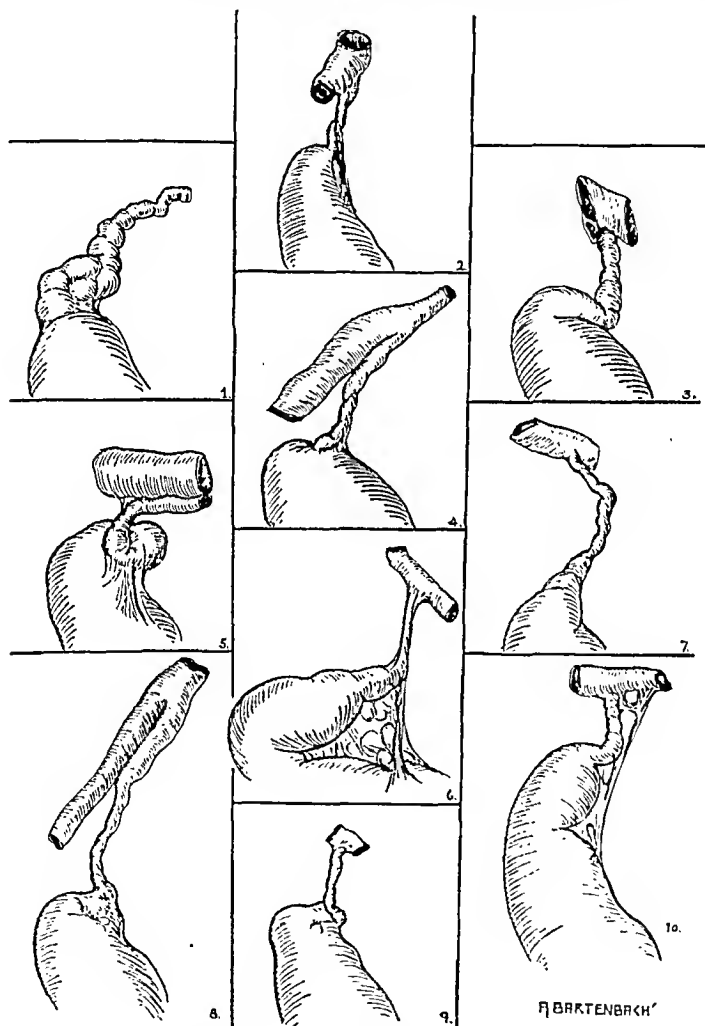


Fig. 4.—Variations in shape of cystic duct.

a downward displacement of the body of the gallbladder with angulation at the neck and duct.

Observations on the size, form variations, modes of union of the cystic duct with the common hepatic duct, and the relations of the cystic artery are of interest (Table I).

TABLE I

I. LENGTHS OF NECK AND DUCT OF GALLBLADDER

CM.	NECK	CYSTIC DUCT
0-1	2	1
1-2	22	19
2-3	16	28
3-4	7	27
4-5	2	12
5-6	0	7
6-7	1	3
7-8	0	2
8-9	0	0
9-10	0	1
No. of specimens	50	100
55 per cent of cystic ducts are between 2 and 4 cm. in length		
20 per cent of cystic ducts are less than 2 cm. long		
25 per cent of cystic ducts are more than 4 cm. long		

II. CIRCUMFERENCE VARIES BETWEEN 4 AND 10 MM.

AVERAGE CIRCUMFERENCE IS 6 MM.

III. FORM VARIATIONS:

Spiral
Kinked
Constrictions
Knots
Tortuous

IV. CYSTIC DUCT UNITES WITH HEPATIC DUCT:¹⁵

Angular	(292 in 389 instances)
Parallel	(64 in 389 instances)
Spiral	(67 in 626 instances)

From evidence submitted by Boyden¹³ and Rietz,¹⁴ it appears that the peculiar conformation of the cystic duct and neck of the gallbladder is due to the accommodation of a rapidly growing tube in the slower growing mesenchymal bed of the gallbladder (Fig. 7). Since the bed limits the extent of growth, the gallbladder develops folds and twists which are more exaggerated at the neck and cystic duct. Further limitation of longitudinal growth occurs here, because the cystic artery fixes the space available for the neck and cystic duct.

There is much to support this view. The folds which appear in the lumen of the duct and neck of the gallbladder appear to be more marked in the young and tend to be more flattened in the old. In the embryo, a spiral-like "valve" is present, but this spiral partly disappears in the adult or is flattened so that only segments are left which are connected by newly developed small folds in the mucous membrane. The valves or folds are most discernible in that portion of the duct close to the neck of the gallbladder and decrease in number in the more distal portion of the cystic duct. It is rare to find "valves" in the distal portions of exceedingly long cystic ducts, but it is common to find them throughout the whole extent of short ducts. It must be understood, too, that folds may appear in the body of the gallbladder (folded fundus, folded body) and for the same reason. Examination

Practically all forms of liver displacement tend to straighten out the cystic duct, but marked ptosis may produce a very acute bend in the cystic duct near its junction with the common hepatic duct, thus favoring obstruction.

Adhesions may fix the gallbladder to adjacent viscera, or by traction prevent the outward displacement of the gallbladder, or produce

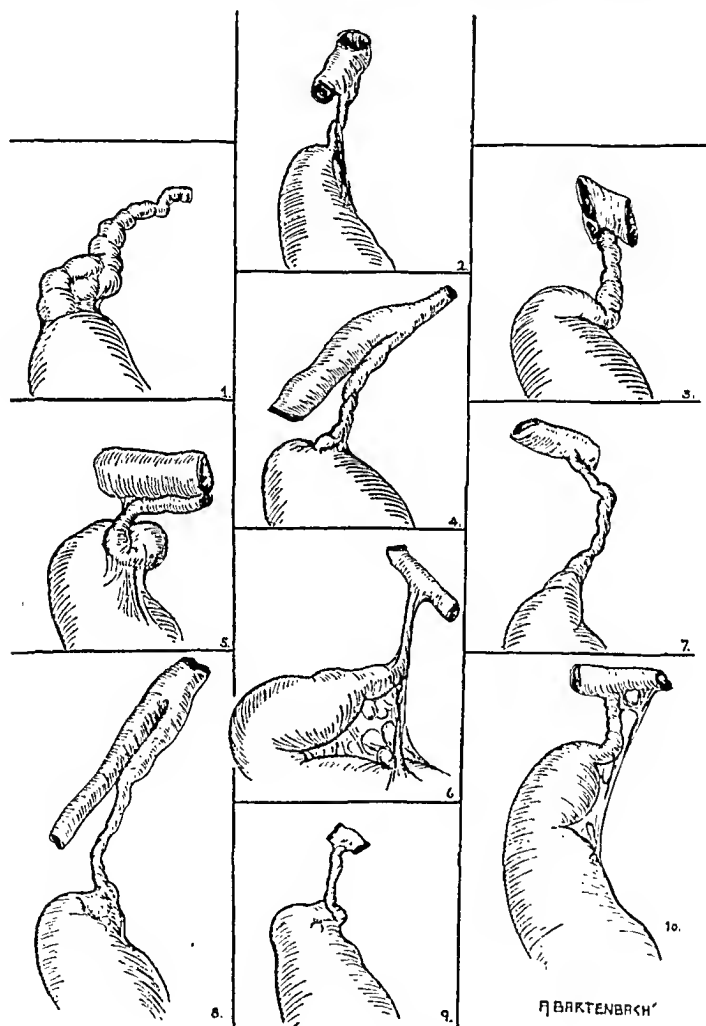


Fig. 4.—Variations in shape of cystic duct.

a downward displacement of the body of the gallbladder with angulation at the neck and duct.

Observations on the size, form variations, modes of union of the cystic duct with the common hepatic duct, and the relations of the cystic artery are of interest (Table I).

posture has limited the space in the upper abdomen for accommodation of the liver. Also, the development of folds and ligaments, such as

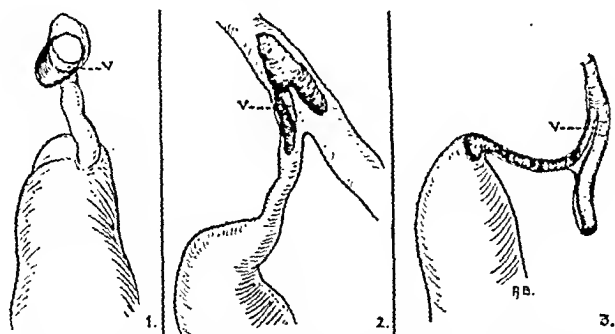


Fig. 6.—At "V" is the small leaflike process which appears to arise by the fusion of the walls of the cystic and hepatic ducts.

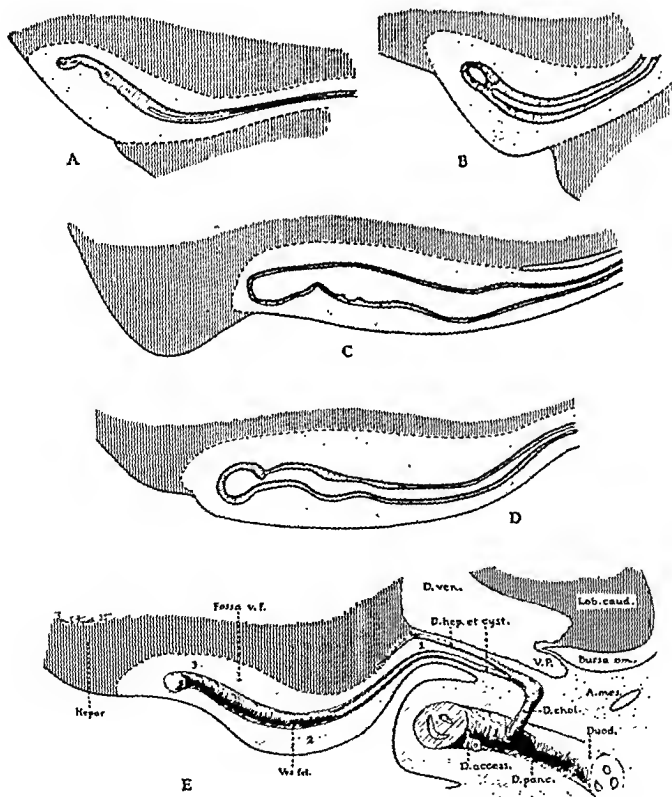


Fig. 7.—From Boyden.¹³ Stages in the development of the gallbladder. In E note the three sites (1, 2 and 3) at which bends may occur.

Keith and Lane have described, to fix the viscera in the upright position may have been responsible for the twisting of the cystic duct, which resulted in the formation of the "valves."

of the mucous membrane projections into the lumen of the gallbladder shows that these folds are similar to the folds of the cystic duct associated with the "valves." Where large folds have occurred, these may be straightened with disappearance of the "valve" in the interior of the gallbladder (Fig. 3).

This embryologic origin of the "valvular" folds also accounts for the variable number of folds from complete absence to as many as twenty and accounts for the peculiar twists, knots, kinks, spirals, and

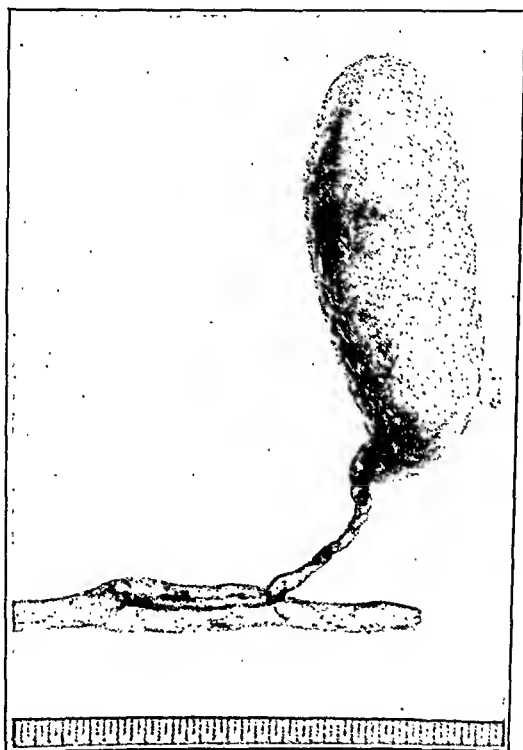


Fig. 5.—The cystic duct. Note that the pars glabra is wider in diameter than the pars convoluta.

other formations which tend to show an effort was made to accommodate a long tube in a limited space. Since gallbladders vary in size and the liver beds also vary in size, the extent of folding in each individual case will depend on the relationship between the developing gallbladder and its mesodermal bed.

PHYLOGENY

It is of interest to note that phylogenetically the "valves" of Heister appear only in primates. It is possible that the assumption of the erect

B 5. Likewise, the pressure in the common duct may be elevated by opening the clamp, *A* 4, and it may be decreased by opening the clamp, *A* 5.

II. In some instances the body of the gallbladder was removed, and the cannula was placed into the infundibulum with its orifice facing the beginning of the neck. This was proximal to the first bend and also to the first Heister valve (Fig. 8*b*).

III. To determine more accurately the effect of the presence of the valves of Heister on the flow of fluids through the cystic duct, the apparatus was arranged as in Fig. 8*c*. In these experiments only the straight portion of the cystic duct was used. The cannula was placed into the neck of the gallbladder so that the orifice of the cannula just entered the straight part of the duct. The cannulas in the hepatic and common ducts were so placed that they did not interfere with the passage of fluid into the orifice at the termination of the cystic duct.

The ducts were placed on a level plane in line with the 0 mark on the manometers. The three locations of the cannulas on the gallbladder side of the cystic duct were associated with slightly different results.

RESULTS

I. Using several methods of observing the flow of fluids through the cystic duct with the gallbladder intact, it was found that the results were approximately similar to those following the use of the apparatus illustrated. With high pressures (over 15 cm. of solution), equalization of pressure takes place promptly. The ducts are dilated, the neck of the gallbladder stands erect, and there is no obstacle to the passage of fluid through the cystic duct in either direction. With lower pressures, equalization occurs on both sides of the cystic duct, but there remains a slightly higher pressure on the side of active flow. When fluid passes into the gallbladder, the pressure in the common duct is slightly higher than that in the gallbladder. Likewise, when fluid passes into the common duct, the pressure is slightly higher in the gallbladder. These results confirm the findings of Johnson and Brown.

II. Using the second type of preparation in which the body of the gallbladder is removed (Fig. 8*b*), the following differences in results were noted as compared to the first type (Fig. 8*a*) of preparation:

1. No filling of the gallbladder was necessary, hence the rise in pressure occurred almost immediately on the opposite side of the cystic duct.

2. At approximately 5 cm. pressure, equalization in pressure occurred promptly. At 2 to 3 cm. pressure or lower, a lag in equalization was noted.

It is difficult to correlate the size of the liver or the number of lobes of the liver with the station of the species in the mammalian scale. In general the liver in man is smaller, however, in proportion to the size of the body, than in any species except that of the goat and horse.

METHOD OF INVESTIGATION

I. Specimens of human gallbladders with their attached ducts (cystic, hepatic, and common) were obtained at autopsy within twelve to twenty-four hours after death. The cystic artery, which attached the body to the neck of the gallbladder in such a manner as to preserve the bend at their junction, was left intact. The hepatic duct was

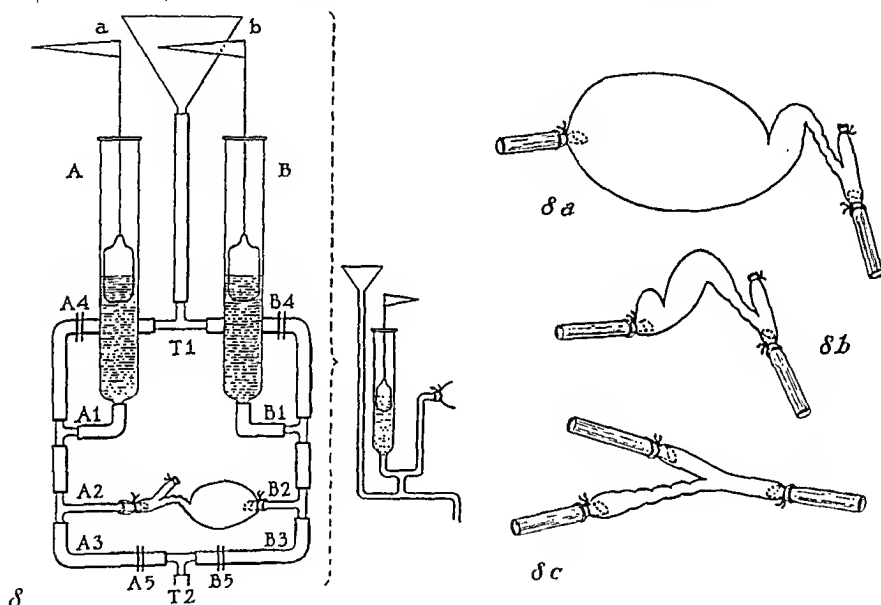


Fig. 8.—Apparatus and types of preparations.

ligated. The common duct and fundus of the gallbladder were cannulated and attached as indicated in Fig. 8a. The cannulas had a diameter that approximated that of the cystic duct.

Salt solution (0.9 per cent) passes from the funnel into the arms *A* and *B* of a T-tube, *T 1* (Fig. 8). It is then carried to *A 1* and *B 1*, which are connected with a water manometer having floats, *a* and *b*; and to *A 2* and *B 2*, which are attached to cannulas in the gallbladder and common duct; to *A 3* and *B 3*, which lead into a flask through a common tube, *T 2*. Clamps are placed at *A 4*, *B 4*, *A 5*, and *B 5*. The pressure in the gallbladder may be elevated by opening the clamp at *B 4*. This pressure may be recorded on a smoked drum by the float, *b*. The pressure may be decreased in the gallbladder by opening the clamp,

DISCUSSION

From these findings it would appear that the "valves" themselves offer no resistance to the passage of fluids in either direction, that the bends at the junctions of the neck with the gallbladder on one side and the cystic duct on the other offer a slight degree of resistance to the flow of fluid both into and out of the gallbladder, and that when the pressure in the gallbladder is sufficient to cause a straightening of the neck, fluid will pass unobstructed out of the gallbladder. As is well known, it is rare to find an empty gallbladder. This may be due to the necessity of having an appreciable pressure, though small, to maintain a patent passage between the gallbladder and cystic duct.

When one observes formalin hardened specimens of cystic ducts which have been cut open longitudinally, one finds that the direction of the pockets formed by these leaflets faces in some instances toward the common duct, as though to impede the entrance of material into the gallbladder, while in other instances it faces toward the neck of the gallbladder. Yet dark, thick bile obtained from the gallbladder and poured into a cannula attached to the common duct will flow into the gallbladder under a pressure of 2 to 3 cm. of bile pressure. How much of this 2 to 3 cm. pressure is due to the resistance of the caliber of the tube could not be determined. As the hepatic bile is much thinner than gallbladder bile, it is not likely that the "valves" offer any resistance to the flow of bile into the gallbladder.

That some should suggest impediment of outflow of bile from the gallbladder is likely from the fact that gallbladder bile is more viscous than hepatic bile and must pass through the narrowest portion of the extra hepatic biliary passages, whose lumen is further limited in size by the presence of the "valves." The facts are, however, that gallbladder bile is able to pass through the cystic duct and empty into the more commodious common duct.

The presence of valves in the cystic duct does not seem to impair the passage of 0.9 per cent sodium chloride solution, or tap water, or gallbladder bile in either direction.

It has been suggested that the valves act as baffle plates to permit inflow and outflow simultaneously. This does not appear likely, as the inflow of bile into the gallbladder is dependent upon an increase in tone of the sphincter of Oddi. This results in an increase in the pressure in the common duct with opening of the orifice at the entrance of the cystic duct into the common duct.

When the sphincter of Oddi is relaxed, hepatic bile will flow directly into the duodenum. The only manner in which the gallbladder will fill is by an increase in pressure in the common duct. When the gallbladder evacuates its contents, the pressure in the common duct falls.

III. Using the "setup" shown in Fig. 8c, equalization of pressures on either side of the cystic duct was immediate, with pressures varying from 3 mm. to 200 mm. 0.9 per cent NaCl. The sizes of the ducts are recorded in Table II.

TABLE II
SIZE OF CYSTIC DUCT IN CM.

LENGTH	CIRCUM.	"VALVES"
1.5	0.5	4
2.6	0.8	6
3.0	0.6	2
3.4	0.6	4
3.8	0.8	6
4.0	0.6	6
4.0	0.4	5
4.5	0.8	4
4.5	0.6	12
4.8	0.8	7
5.0	0.8	6
5.4	0.8	8
6.4	1.0	4
7.5	0.8	9

SUMMARY OF RESULTS

With the gallbladder intact, an adequate volume of fluid is required to fill the gallbladder before any of it will pass into the cystic duct. The gallbladder must be well filled before sufficient pressure may be attained to force fluid through the neck and cystic duct and to have the fluid appear on the common duct side. When stabilization of fluid levels occurs, it has been found that there remains a residual slightly higher pressure on the gallbladder side than on the common duct side. This amounts to from 0.5 to 3.0 cm. of pressure. Also, when fluid passes from the common duct through the cystic duct and neck of the gallbladder, equalization of pressures to the point of stabilization shows a slightly higher pressure on the common duct side than on the gallbladder side.

These findings are in accord with those of Johnson and Brown. When the second type of preparation was used (body of gallbladder removed), the flow through the tubes was more prompt, but there still remained a slight residual pressure on either side, which was higher than on the opposite side, this higher pressure being on the side of active flow from the funnel.

When the third type of preparation was used, even at the slightest pressure of 1.0 to 3.0 mm. of water, prompt equalization of pressure occurred. These findings were found in specimens that had few (2), as well as many (up to 12), "valvular" projections into the lumen of the cystic duct. Also, this was true, regardless of the size and degree of tortuosity of the cystic duct.

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pressures in the gallbladder or common duct, and to prevent sudden distention or collapse of the cystic duct. Thus, the presence of the "valves" of Heister, when normal, constitutes an anatomic factor of safety which seems to have been associated from the evolutionary viewpoint with the assumption of the erect posture.

APPLIED PHYSIOLOGY

The narrowness of the channel which connects the gallbladder to the common duct predisposes it to obstruction. Edema of the wall or of the mucosa alone, even though slight, may be sufficient to produce interference with the filling or the emptying of the gallbladder. The duration of this obstruction will, to a certain degree, determine the extent of permanent change, since inflammation with damage to the mucous membrane results in altered physiology of the gallbladder. While inflammation may occur in the gallbladder or the hepatic and common ducts, the narrow, tortuous channel in the cystic duct may be more readily occluded.

Anatomic relations of the cystic duct to adjacent organs predispose to pathologic changes. The venous plexus covering the cystic duct may involve the duct, especially when thrombophlebitis or thrombosis of the veins takes place. The cystic artery, too, may be involved in an inflammatory process and cause a change in the vascularity of this part. Angulation of the duct and the presence of swollen lymph glands adjacent to the cystic duct may also serve to produce obstruction.

SUMMARY

The "valves" of Heister arise late in the phylogeny of the mammalian kingdom. They are found only in primates. The human gallbladder is derived from a rapidly growing tube lying in a more slowly growing mesodermal bed. This difference in growth causes numerous foldings and windings to occur so that the gallbladder may be accommodated in its liver bed of limited space. The cystic artery early in development limits the longitudinal growth of the neck and cystic duct. Folds occur commonly in the fundus and body of the gallbladder and represent the most frequent anomaly of the human gallbladder. The "valves" of Heister are an embryological formation due to the winding or longitudinal compression of the duct during its development. The variations in the number and size of the "valves" and their absence in the more distal portion of the cystic duct are due to the variations in the size of the parts that take part in the foldings and winding. Our studies show that pressure variations on either side of the valvular portion of the cystic duct are not influenced by the presence of the "valves." Variations in pressure noted by Johnson

This indicates that the flow into or out of the gallbladder is unidirectional at any time, and there is, therefore, no need for baffle plates to permit bidirectional flow at the same time.

It has been suggested that the free passage of fluid through the cystic duct does not occur unless sufficient pressure has been established to distend the duct system. Some have gone so far as to state that a sphincter is present between the body and neck of the gallbladder. It appears that in the intact gallbladder there may be an obstacle to the progress of fluids into or out of the gallbladder between the body and the cystic duct. While no definite sphincter has been demonstrated, one must admit the possibility that a sphincter may exist without an organized muscle band that can be demonstrated anatomically. The cardiac sphincter of the stomach is an illustration of such a possibility. In examining the gallbladder, however, one finds that the two locations where sphincters have been suggested are anatomical sites of bends in the continuity of the gallbladder. These bends in some instances represent a change in direction amounting to 180°.

The cystic duct is an anatomical pathway between the reservoir for bile on one side and the ducts connecting the liver to the duodenum on the other. It is subjected to varying pressures, from the gallbladder up to 25 cm. of bile pressure, and from the common duct up to 80 cm. of bile pressure. The gallbladder pressure is acquired directly from the tonic contraction of its musculature and possibly to some extent indirectly from the pressure of adjacent viscera or is transmitted from the thorax. In the common duct, the pressure is determined by the action of the sphincter of Oddi plus the tone of the duodenal musculature. The cystic duct is devoid of any organized system of musculature, which by itself could by contraction produce changes in the internal pressure in the cystic duct.

Thus, the cystic duct is a pathway through which bile is passing either into or out of the gallbladder. It is subjected to variations in pressure which take place normally on either end. These pressure changes may be a cause for sudden distention. The presence in the cystic duct of numerous nerve ganglia makes this a sensitive portion of the extra hepatic biliary passages. It is possible, therefore, that the existence of the "valves" of Heister is to retard the distention of the duct during the changes in pressure. Also, as suggested by Keith, they may maintain the patency of the lumen. In those instances where the distal portion of the cystic duct is devoid of valves (*pars glabra*), dilatation may be present (Fig. 4). This would indicate that the folds in the *pars convoluta* prevent dilatation of the cystic duct. The folds, or "valves," of Heister simply constitute an architectural device to maintain the uniform size of the duct in the presence of changing

NUTRITIONAL EDEMA: ITS EFFECT ON THE GASTRIC EMPTYING TIME BEFORE AND AFTER GASTRIC OPERATIONS

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ONE of the most common conditions with which surgeons are confronted is malnutrition. Its existence is far more widespread than is commonly believed, and its effects, while generally thought to bear some relationship to resistance, are actually of a more profound character. Prolonged restriction of protein in the diet causes a reduction of the plasma proteins. The chief function of the proteins in the blood is to maintain the colloid osmotic pressure of the circulating blood.¹ As Starling² has pointed out, the osmotic pressure of the plasma crystalloids, although relatively large (5,000 to 6,000 mm. of mercury) as compared with that of the plasma proteins (30 mm. of mercury), is of little importance in the normal fluid distribution, because crystalloids pass freely through the walls of blood vessels. Govaerts³ and Schade and Claussen⁴ found that as the plasma proteins were reduced from their normal of 7 per cent, the osmotic pressure exerted by the plasma was proportionately reduced. Weech and his coworkers⁵ have shown that as the plasma proteins are reduced in concentration, the circulating fluid begins to leave the vessels, resulting first in a latent, and later in an evident edema. Their work indicates that the so-called critical level for edema (usually stated to be 5.2 gm. of protein per 100 c.c. of blood) is but the level at which edema becomes clinically manifest. This rôle of the plasma proteins, wherein they play an important part in maintaining a delicate state of balance between the blood and the intercellular fluid, is of particular importance to the surgeon. The observation that surgical patients may exhibit a definite hypoproteinemia, with or without edema, is becoming more generally accepted. Jones and Eaton⁶ reported thirty-four cases which they had personally observed. We have observed six patients with hypoproteinemia in our surgical service in the past eight months. It is interesting to note that with the exception of the

and Brown, and Lohner are probably due to the presence of the bends in the neck of the gallbladder. Inflammation of the "valves" may be responsible for obstruction of the cystic duct.

CONCLUSIONS

The function of the "valves" of Heister (if a function is to be ascribed to this anatomie formation) is to prevent distention or collapse of the cystic duct when sudden change of pressure occurs in the gallbladder or common duct. The folds, or "valves" of Heister, constitute an architectural device to maintain the uniform size of the duct in the presence of changing pressures in the gallbladder and common duct. Thus, the presence of the "valves" of Heister, when normal, constitutes an anatomical factor of safety which seems to have been associated from the evolutionary viewpoint with the assumption of the erect posture.

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there was no evidence that the stoma was functioning. At this time the serum proteins were 5.1 gm. per 100 c.c., and roentgen studies showed almost complete obstruction at the site of the stoma (Fig. 1). Peripheral edema was evident. We were successful at this time in passing a Levine tube through the patient's stoma, through which vigorous protein therapy was instituted. In addition to this the patient was given repeated blood transfusions. Within three days, there was marked clinical improvement, and roentgen studies on the twenty-ninth postoperative day disclosed a normally functioning stoma (Fig. 2).

It was exceedingly difficult to refrain from doing a secondary operation when roentgenographic evidence of obstruction was obtained, but a regime which tended to re-



Fig. 2.—Gastrointestinal roentgenogram thirty minutes after the administration of barium and twenty-nine days after operation.

store the plasma proteins resulted in their rapid rise and complete disappearance of the supposed technical defect in the anastomosis. We had observed a similar instance of this condition as early as 1928. In this patient, restriction of fluid intake and blood transfusions resulted in a functioning stoma. It occurred to us that not a few of the patients who were subjected to secondary operations after surgical procedures for gastric or duodenal ulcer, or malignancy, might in reality be examples of a profound disturbance of the plasma proteins with a state of edema affecting the site of the anastomosis. It seemed important to test the hypothesis that a relationship existed between gastric retention and the nutritional state.

paper by Jones and Eaton in 1933 and the papers by Ravdin in 1935,^{7, 8} the importance of nutritional edema affecting the gastrointestinal tract has not been stressed by writers on gastrointestinal surgery. We have on a number of occasions had evidence that a reduction of the plasma proteins may cause such changes in the gastrointestinal tract after gastrointestinal operations, that the postoperative picture mimics in every way a technical defect of the anastomosis. The following case history is illustrative:



Fig. 1.—Gastrointestinal roentgenogram twenty-four hours after administration of barium and nineteen days after operation.

CASE 1.—W. S., male, aged forty-two, was admitted to the Surgical Division of the Hospital of the University of Pennsylvania on September 18, 1933, with a diagnosis of duodenal ulcer. The roentgen studies had disclosed a marked pyloric obstruction. Restriction of food intake had resulted in a loss of forty-eight pounds. There was no evidence of peripheral edema; the patient, on the contrary, showed definite evidences of dehydration. On admission the hemoglobin was 102 per cent and the plasma proteins were 7.8 gm. per 100 c.c. of blood. A pylorotomy was performed with reconstruction of the gastrointestinal continuity by the Polya technic. Subsequent to operation the patient was given normal saline solution intravenously, and siphon drainage of the stomach was instituted. On the nineteenth day after operation,

the experiments and the one found most satisfactory was a modification of several previously reported. The total stock diet was made up as follows:

Carrots	10 pounds	4.5 kilograms
Turnips	10 pounds	4.5 kilograms
Rice	4½ pounds	2.0 kilograms
Oleomargarine	3½ pounds	1.6 kilograms
Karo	3½ pounds	1.6 kilograms
Cod liver oil	100 cubic centimeters	
Bone ash	50 grams	
Sodium chloride	100 grams	
Yeast concentrate	5 grams	

The carrots and turnips were coarsely ground and were boiled for twenty minutes along with the rice. The other ingredients were then added, with the exception of the cod liver oil and yeast, which were not added until the mixture had cooled. The stock food was carefully mixed and kept in a refrigerator room. The dogs were given daily all they desired, care being taken that each animal received at least double its basal caloric requirement. The protein content was approximately 1 per cent.

It was found that the injection of a normal saline solution into the saphenous vein to equalize the amount of blood withdrawn from the femoral artery facilitated the plasmapheresis. By this means as much as 950 c.c. has been withdrawn from a dog weighing 9 kg. without producing any distressing symptoms. It is obvious that the protein content of the mixture of blood and saline is not as high as that of whole blood, but the lack of evident shock enables the worker to take the time to wash the corpuscles before replacing them intravenously.

Three groups of experiments were carried out. First, the effect of hypoproteinemia on the gastric emptying time was determined on unoperated dogs. In the second group, animals were made hypoproteinemic and then were subjected to pyloric resection with restoration of the gastrointestinal continuity by gastroduodenostomy or by the Billroth II principle. The gastric emptying time was determined at critical periods of the experiment. After a period of hypoproteinemia, the proteins were permitted to rise and at a subsequent period were again reduced. In group three, dogs which had Polya operations performed on them at least a year previously were studied. These animals were checked weekly as the proteins were lowered, raised, and then lowered. Needless to say, not all the animals survived the rigors of the course outlined for them.

RESULTS

Group I was composed of ten dogs, eight of which survived the low protein diet and repeated plasmapheresis for more than one month. Of the eight animals, two showed little change in their gastric empty-

METHOD

Dogs were chosen as the experimental animal for the following reasons: first, their size, which (a) facilitated plasmapheresis, (b) made it possible to take frequent blood samples, (c) made operative procedures satisfactory; second, the ease with which the dog could be adjusted to an unusual diet; third, the facility with which the animal could be trained to lie quietly before the fluoroscope. There were definite objections to the use of this animal. It normally has a low standard level of plasma proteins (mean about 5.8 per cent) and furthermore, different animals show a marked variation from the normal (5.0 per cent to 6.8 per cent). It resists the production of clinical edema, and it has a high susceptibility to distemper when malnourished.

The animals were carefully watched for changes in their physical state. The gastric emptying time and serum proteins were determined at least weekly. Total proteins only were determined. Weech, Reeves, and Goettsch⁹ have demonstrated that the globulin fractions maintain a fairly constant level even when there is a marked decrease in the serum albumin. Thus, total protein values reflect changes in the more important albumin fraction. The Moore and Van Slyke¹⁰ specific gravity method was used because of its simplicity, rapidity, and high degree of accuracy; which last compares favorably with Kjeldahl determinations. In determining the proteins, serum was used instead of plasma because of greater accuracy.¹¹

A special 2 c.c. specific gravity bottle having a fine capillarity is required for the test. It should be rimmed with stopcock grease to prevent evaporation of its contents. It is carefully filled with serum, weighed accurately to within 0.1 mg., and corrected to 20° C. Per cent total serum proteins may be calculated from the following formula:

$$\text{Per cent total serum protein} = \left\{ \frac{\text{Weight of serum at } 20^{\circ} \text{ C.}}{\text{Weight of water at } 20^{\circ} \text{ C.} - 1.007} \right\} \times 343$$

Care must be taken to keep all apparatus dry, preferably in a desiccator, to wipe away all excess serum or water before weighing, and to allow the samples to reach the temperature of the balance case before the final weighing. It is advisable to check all results by using two or more bottles. Variation between checks should not exceed 0.05 per cent.

Blood chloride determinations were made at critical stages in the experiments and were in every case within normal limits.

Hypoproteinemia was produced by diet and plasmapheresis. It was not found practical to plan in advance the number of plasmaphereses required in any particular animal, or the length of time the animal should be kept on a restricted diet. Numerous diets were tried early in

After operation, while the serum proteins were low, there occurred a definite delay in the gastric emptying, despite strong gastric contractions on fluoroscopic examination (Fig. 4). All of the animals showed speeding of the gastric emptying as the proteins were restored to normal (Fig. 5). The two animals having their serum proteins reduced a second time showed slowing of their emptying times as hypoproteinemia was again induced.

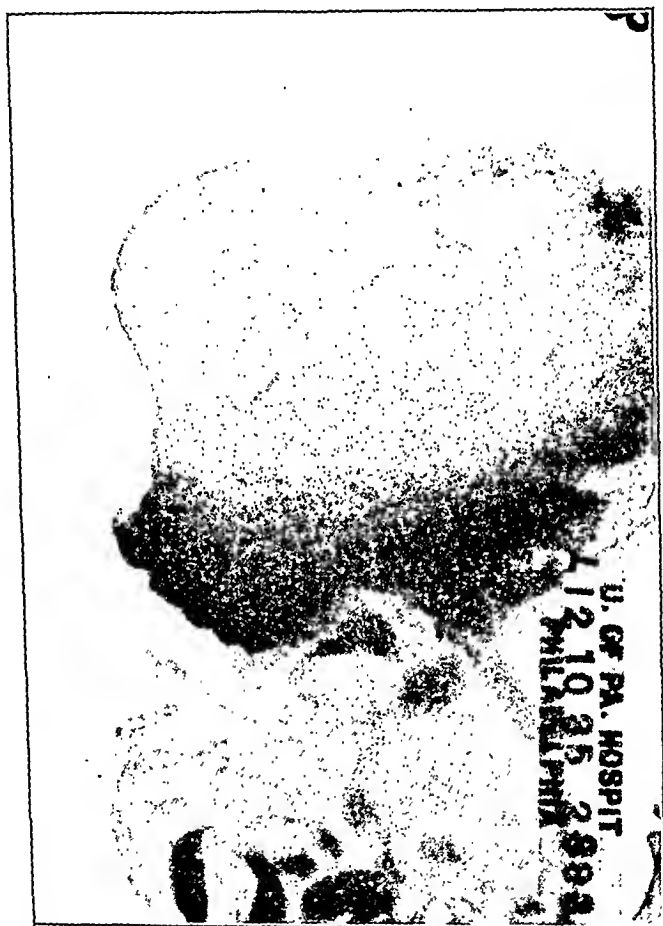


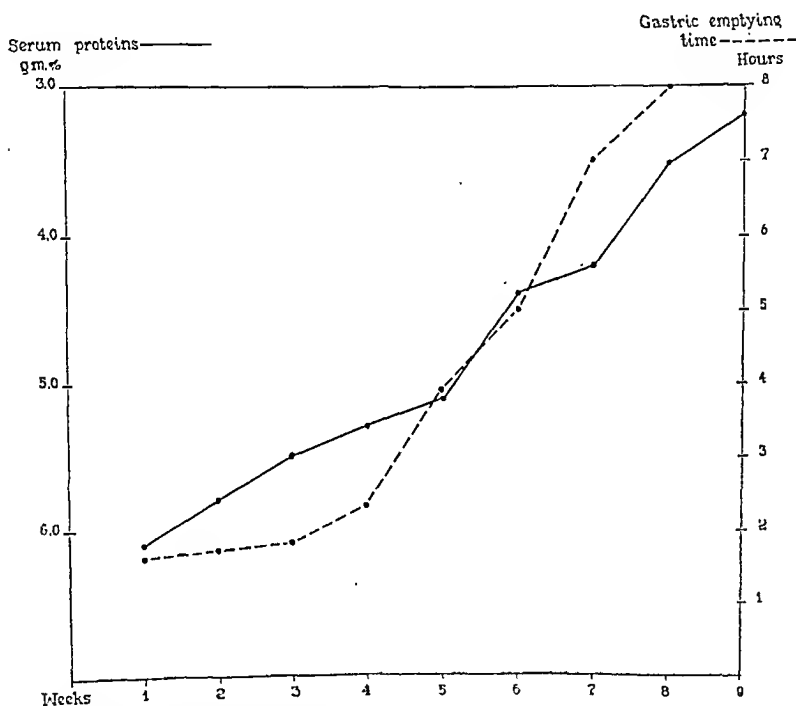
Fig. 4.—Fluoroscopic examination in a dog with low serum proteins.

In one of the dogs all fluids were withheld for several days. The gastric emptying time was speeded up. Following this, 800 c.c. of normal saline solution were given intravenously. The serum proteins fell and the gastric emptying was retarded (Fig. 6).

Group III consisted of two animals which had been subjected to the Polya operation over a year before the beginning of this experiment. Their gastric emptying time was studied repeatedly while they were

ing time as the serum proteins were reduced. One of these had a nearly normal emptying time despite a serum protein of 2.73 per cent. At postmortem twenty-four hours later, there was obvious edema of the gastrointestinal tract.

The remaining six animals showed varying degrees of retention of the barium meal as the serum proteins were lowered. In one dog the gastric emptying time after reduction of the serum proteins was fifty times the normal for this animal, while in another it was thirty times the normal. In general in this group the lower the serum proteins, the longer was the gastric emptying time (Fig. 3).



Dogs 44 46 47 49 150 299 351 352 — Group I.

Fig. 3.—Group I. Mean values for serum proteins and gastric emptying time.

Group II was composed of three dogs which when hypoproteinemic were subjected to pylorectomy. In two of the three animals in this group the serum proteins were reduced a second time after recovery from the initial low values. In the first period of low protein diet, none of the animals had total serum protein values below 4.0 per cent. This may be roughly compared to a serum protein of 5.5 per cent in the human being. In our experience it was the lowest value we were able to obtain and keep the animals well enough to regain a normal serum protein after the addition of sufficient protein to the diet.

on a normal animal house diet and after varying periods of a low protein diet and repeated plasmapheresis (Fig. 7).

The dogs showed a marked retardation of the gastric emptying time as the serum proteins fell. In Dog No. 687, as the serum proteins were restored to normal, the gastric emptying time was speeded up to that observed during the control period. When the serum proteins were reduced a second time, the gastric emptying time as observed fluoroscopically was not retarded as it was on the first period of hypoproteinemia, although there was definite clinical evidence of gastric retention. This was manifested by the retention of gastric contents as evidenced by the daily passage of a stomach tube.

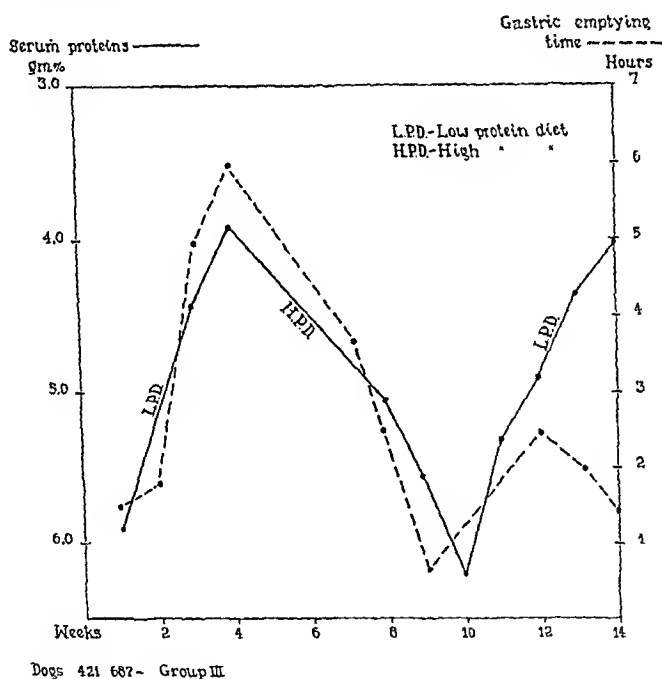


Fig. 7.—Group III. Mean values for serum proteins and gastric emptying time.

DISCUSSION

There are several possible explanations for the observed delay in gastric emptying time in hypoproteinemic patients and animals. First, the reduced vitality observed in the hypoproteinemic dogs may have an expression in a diminution of gastric activity. Second, the edema of the gastric tissues may interfere with effective muscle contraction. Third, the reduction in the size of the stoma coincident with the edema may so interfere with emptying as to result in the observed retention.

We are inclined to believe that this latter explanation is the correct one. All of the animals with total serum proteins of 4.0 per cent or lower showed gross edema of the stomach at postmortem or operation.

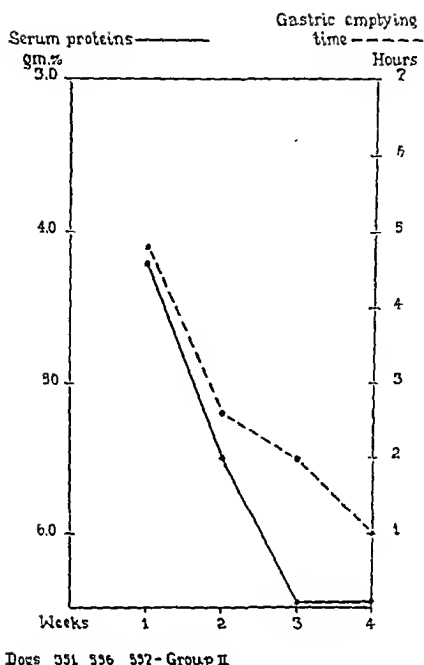
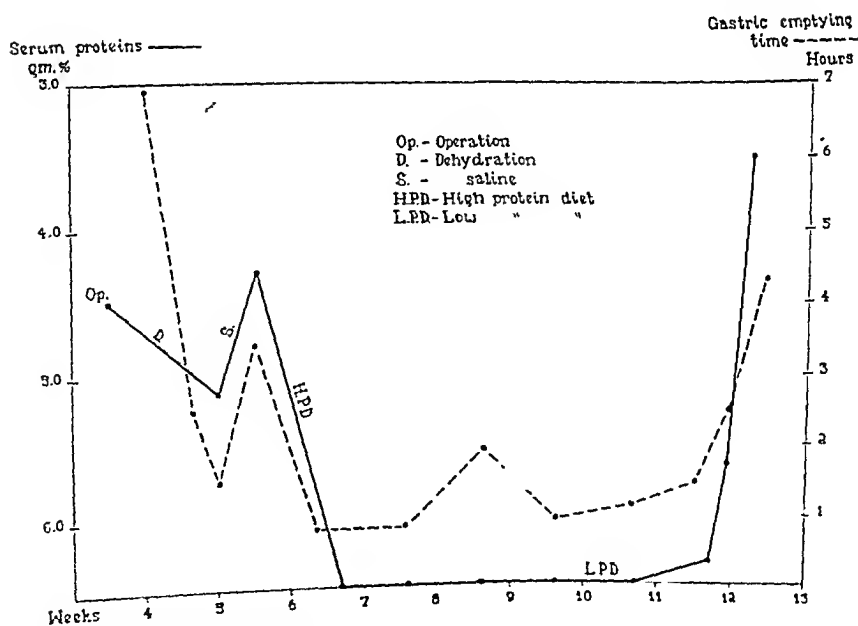


Fig. 5.—Group II. Mean values for serum proteins and gastric emptying time.



Dog 557 - Individual from Group I.

Fig. 6.—Effect of high and low serum protein on the gastric emptying time in dog No. 557.

permit subsidence of the reaction to the trauma of operation. In four of the five instances, the edema was such as to cause a very marked reduction in the size of the stoma.

It was a general observation, during fluoroscopic examination of the animals having edema, that the gastric tone was normal or increased, and that the peristaltic waves were equal to, or greater than, their normal depth, although motility was practically absent. The fluoroscopic picture was similar to that observed during pyloric obstruction.

During this investigation, several observations of a general nature have been made. In our experience animals rendered definitely hypoproteinemic all developed ulcers over their forelegs and ankles. These ulcers increased in size as the proteins were further reduced and healed rapidly as the proteins were raised. Marked difficulty was noted in healing of the abdominal incisions of hypoproteinemic animals. When the proteins were raised, the wounds healed promptly. It was interesting to note that we have seen two instances of intestinal perforation in hypoproteinemic animals. One was a perforation of an ulcer in the proximal duodenal stump five weeks after operation, and the other was a perforated gastrojejunal ulcer fifteen months after the operation.

Despite the fact that the dogs maintained on the low protein diet consumed more than double their basal caloric requirements, they invariably lost weight which amounted in several instances to as much as 40 per cent of their original body weight. Although the proteins were raised from a level of 4.0 per cent to a normal figure in approximately three to four weeks on the high protein diet alone, the gain in weight proceeded at approximately half that speed, and in no instance, even after two months, was the original weight regained. Animals in the hypoproteinemic state were, in our experience, extremely susceptible to distemper. None of our dogs received prophylactic injections.

Numerous opportunities were afforded to study the dilution of blood plasma caused by intravenous injections. On seven occasions an average of 375 c.c. of normal saline caused the proteins four hours after the infusion to be reduced from a mean of 4.6 to a mean of 3.7 per cent.

Clinically, latent or manifest edema is most frequently seen in cases of nitrogen starvation, general malnutrition, purulent and serous drainage, hemorrhage, severe diarrhea, and following the administration of large amounts of sodium salts. It has been indicated by Weech and Ling,¹² by Lepore,¹³ and others that, if the sodium ion is restricted, it is difficult to produce edema in either dogs or human beings regardless of the plasma protein level. There is good evidence that as the plasma proteins are reduced from their normal levels, diminishing amounts of fluid and sodium salts are required to cause edema. It must

The same state has been observed in human patients with hypoproteinemia. When operation has been resorted to, the increased edema incident to trauma further reduces the caliber of the stoma.



Fig. 8.—Photomicrograph showing submucosa and muscularis of the stomach of a normal dog. Total serum proteins 6.20 gm. per cent. ($\times 50$.)



Fig. 9.—Photomicrograph showing edema of the submucosa section from animal having total serum proteins of 2.73 gm. per cent. ($\times 50$.)

Sections of the specimens removed from the stomach demonstrate the edema (Figs. 8 and 9). We have examined the stoma at post-mortem in five hypoproteinemic dogs subjected to the Polya operation and in which the period following operation was sufficiently long to

INTESTINAL OBSTRUCTION COMPLICATING PREGNANCY

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THE possibility of pregnancy per se causing intestinal obstruction will probably be questioned by a great many obstetricians and surgeons. In none of the standard textbooks on obstetrics or surgery is there any reference to pregnancy itself being an etiologic factor in ileus. Leonard¹ in 1917 writes that "normal intrauterine pregnancy rarely if ever causes acute obstruction per se." A French author, Pinard, states, "I have never seen intestinal occlusion complicate a normal pregnancy." Wilms, in his monograph, *Der Ileus*, makes the statement that ileus caused by pregnancy alone belongs to the rarest of conditions. With this point of view prevailing, it was thought worth while to present three cases in which the most likely cause of the ileus was the normal intrauterine pregnancy. Briefly, the other causes of intestinal obstruction complicating pregnancy are also discussed.

The broader field of obstruction complicating pregnancy has received very little attention from English authors. The German literature, however, is relatively rich with contributions on the subject. Ludwig² in 1913 was able to gather 95 cases from the literature. The etiology and mortality in these cases are shown in Table I. Von Mikulicz-Radecki³

TABLE I
COLLECTED CASES TO 1913 (LUDWIG)

ETIOLOGY	NO. OF CASES	DEATHS	UNKNOWN	MORTALITY
Adhesions	28	17	2	65%
Volvulus	13	9	1	75%
Invagination	4	3		75%
Pregnancy	10	4	1	44%
Hernia	7	3		43%
Miscellaneous (Including tumors, cysts, exudates, etc.)	33	13		39%
Total	95	49	4	54%

collected all the reports from 1913 to 1926 and found 74 cases, to which he added 7 more from his own clinic. These are summarized in Table II.

TABLE II
COLLECTED CASES 1913-1925 (MIKULICZ-RADECKI)

ETIOLOGY	NO. OF CASES	DEATHS	UNKNOWN	MORTALITY
Adhesions	15	6		40%
Volvulus	34	14	4	47%
Invagination	3	3		100%
Tumor	4	2		50%
Pregnancy certain	10	2		20%
Pregnancy uncertain	8			
Unknown	6		6	
Total	80	27	10	39%

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be remembered that the evident edema of the subcutaneous tissues is but an external manifestation of a general process and as such requires active therapy if the patient is to survive.

Therapeutic procedures include transfusion, salt restriction, administration of aaceaia and a high protein diet. Liu, Chu, Wang, and Chung¹⁴ had a remarkable opportunity to test the powers of various foodstuffs in regeneration of the plasma proteins. They concluded that 1 gm. of animal protein was equivalent to 2 gm. of vegetable protein. Soy beans seem to be the exception to this. Indeed, McNaught and his coworkers¹⁵ maintain that it is the best food for rapid regeneration of the proteins.

As prophylaxis against edema formation Jones and Eaton,⁶ in their excellent clinical paper, warn against too free an administration of alkali in ulcer patients. They recommend also that not over 3,000 c.c. of normal saline solution be given daily. They suggest determinations of blood plasma proteins in all patients in whom there is a possibility of hypoproteinemia. It must be stressed, however, that a dehydrated patient may show normal or even high plasma proteins. Yet once the dehydration is overcome, the patient may be found to be hypoproteinemic and may be edematous.

SUMMARY

We have presented data on the effect of a reduction of the serum proteins on the gastric emptying time. In general, the gastric emptying time increases as the serum proteins decrease in concentration. This is true whether the stomach is intact, or whether it has been subjected to a short-circuiting operation. The prolongation in gastric emptying time is associated with edema of the gastric wall. The implications of these findings to the surgeon are pointed out.

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small gut displacement would not come into play. One of the two cases recorded in Table III was due to an epigastric hernia and the other to an umbilical one.

In comparing Tables I, II, and III one notices the greater frequency with which pregnancy per se appears as an etiologic factor in cases reported from 1926 to 1936. This is probably not a true state of affairs, but due to the great interest shown in this subject by the German authors. It is very likely that many cases of obstruction due to the usual etiologic factors, such as adhesions, tumors, volvulus, etc., have not been considered of sufficient interest to report in later years. Therefore, the relative incidence of 10 cases due to pregnancy itself out of 95 cases (Ludwig's² statistics) is a more accurate incidence than 28 cases out of 66 (Eliason and Erb).

These cases of true "pregnancy ileus" have nearly all been proved by excluding other causes either by laparotomy or autopsy. Only a few of them have been accepted as true cases on the clinical course or on the basis of complete relief following emptying of the uterus. The site of obstruction in all the cases has been low in the sigmoid, approximately where the sigmoid crosses the innominate line.

Why pressure from the pregnant uterus should cause obstruction in a very small percentage of pregnancies and not in others, where the same factors appear to be present, is an enigma. Many interesting facts and theories have been advanced to explain this phenomenon. One interlying factor common to all cases is that in pregnancy the female is even more constipated than usual. If, to this manifest lack of tone, other elements are added, one can conceive that the pressure of the pregnant uterus completes the picture. In other words, the pressure of the pregnant uterus itself would be unable to produce obstruction in a normal person. Two of these extraneous factors are clearly illustrated in Cases 1 and 2. In Case 1 the patient had a megacolon, while in Case 3 the paresis following a laparotomy may have so interfered with intestinal motility that the pressure of the pregnant uterus was sufficient to result in complete obstruction. Mechanical factors, such as² retroflexed uterus,¹⁷ hydrocephalus,²⁷ hydramnios, and a congenital adhesion in a case of Leonard's¹ which bound the sigmoid to the lateral pelvic wall and prevented its displacement, are also factors which come into play.

The theory of atonia or disturbance of the vegetative nervous system has its strongest supporters in Stoeckel⁴ and his school. It is discussed especially in relation to the 9 cases in the literature,^{3, 22, 25, 29, 36, 43, 44} in which in addition to an ileus a preexisting severe pyelitis was present. In these cases there was marked stasis and dilatation of ureters, as shown by urograms. Whether this retroperitoneal inflammation was a predisposing cause to a partial paralytic ileus or whether this atony of the ureters is part of some pathologic disturbance is open to conjecture. Some authors even suggested that the intestinal stasis came first, with

Since then, 63 cases have been reported, to which the authors have added 3 from their own experience. Table III shows an analysis of these.

TABLE III
COLLECTED CASES 1925-1935 (ELIASON AND ERB)

ETIOLOGY	NO. OF CASES	DEATHS	MORTALITY
Adhesions	14	3	21%
Volvulus	11	4	36%
Tumors and cysts	7	2	29%
Paralytic (inflammatory)	4	2	50%
Hernia	2	-	---
Pregnancy	28	3	11%
Total	66	14	21%

A review of these figures emphasizes at once the great frequency with which adhesions and volvulus appear as the cause of the obstruction and the infrequency with which strangulated hernia appears.

The cause for this can be explained very logically. The great distortion caused by the growing uterus would naturally change the normal relationships of the abdominal viscera. Adhesions, therefore, which had previously been of no significance, now cause kinking of the bowel and eventually obstruction. This assumption is further confirmed by the

TABLE IV
ILEUS IN RELATION TO MONTH OF PREGNANCY

MONTH	LUDWIG	MIKULICZ-RADECKI	ELIASON AND ERB	TOTAL
1	0	0	0	0
2	1	2	1	4
3	5	1	0	6
4	9	3	6	18
5	9	7	13	29
6	7	12	8	27
7	8	9	6	23
8	8	5	11	24
9th and birth	20	17	19	56
Puerperium	14	11	2	27

incidence of obstruction in relation to the month of pregnancy (Table IV). Both Ludwig² and Mikulicz-Radecki² found that there were three periods during gestation and puerperium when obstruction was more likely to occur: (1) during the fourth and fifth months of pregnancy when the enlarging uterus no longer remains a purely pelvic organ, (2) during the eighth and ninth months when the fetal head again descends into the pelvis, and (3) during delivery and the early days of the puerperium when there is a marked change in the size of the uterus. These three periods represent the times when there is likely to be the most disturbance of the normal intraabdominal relationships.

Strangulated hernia rarely appears as a cause of intestinal obstruction. Ludwig² and Mikulicz-Radecki attribute the displacement of the intestines by the growing uterus, away from the inguinal and femoral rings, as the reason for this relative infrequency. Most of the cases reported are due to umbilical and incisional hernias where this factor of

in the small intestine. The site of obstruction is shown by the barium enema to be located at the rectosigmoid junction when due directly to pregnancy. Great care must be exercised in diagnosing obstruction due to pregnancy in patients with previous laparotomies, because of the likelihood of adhesions.

Every one is agreed that immediate laparotomy following adequate preoperative preparation is the treatment of choice in those cases in which the pregnancy is not the etiologic cause. Several different plans of treatment, however, have been advanced in cases in which no other cause for the obstruction is found. In discussion of this phase of the problem, it was thought worth while to present the following three cases in detail:

CASE 1.—C. S., aged thirty-five years, had an appendectomy in 1927. Date of last period was Sept. 20, 1933. In the third month of her pregnancy she had lower abdominal cramps with bloody discharge, which was diagnosed as threatened abortion. She recovered completely, however, and was perfectly well until three days before admission. Admitted to the Obstetrical Service of Dr. Charles C. Norris, March 3, 1934, at 8:30 P.M. with history of three days' constipation and generalized lower abdominal pain. On the morning of admission she had taken an aperient with no result. Temperature was 99° F., pulse 80, and respirations 24. Abdomen was distended and peristalsis moderately active. No tenderness or rigidity present. The uterus was the size of a five months' pregnancy. Six hours later, enemas were repeatedly unsuccessful and distention had increased. The patient was becoming stuporous. Fluids were given by hypodermoclysis and intravenously. Wangensteen suction was started. An x-ray of the abdomen in the morning after admission revealed gaseous distention of the colon with no gas in the small intestines. Barium enema showed a complete obstruction at the junction of the sigmoid and rectum. Patient was transferred to the surgical service. Findings on admission to surgical service were: temperature 100.2° F., pulse 98, respiration 19, blood pressure, 134/76. Patient intermittently rolled about the bed moaning and groaning with pain. Abdomen was markedly distended, literally "tight as a drum." Peristalsis infrequent, and when heard at all it was definitely tinkling and hollow in character. Percussion was not tympanitic. It was thought unwise to attempt more than a cecostomy. This was done according to the Witzel technic on March 4, 1934. Following this, the patient improved somewhat, though considerable difficulty was still experienced in combating the distention in the large bowel. Because of this, it was decided to sacrifice the child in order to facilitate further surgery, for at this time the diagnosis was carcinoma of the rectosigmoid. After failure of medical induction, a surgical induction of labor (introduction of a Voorhees bag) was attempted on March 13. Patient was finally delivered of a twenty-five-week-old fetus on March 15. On March 20, she had a normal bowel movement. Barium enema on March 27 was negative. Sigmoidoscopic examination on April 2 was negative. The cecostomy tube was now clamped for three days and then removed. Convalescence was uneventful. On September 17, 1935, one and a half years later, a barium enema revealed a megacolon holding 4,000 c.c. of barium with ease. She has remained perfectly well except for chronic constipation.

Discussion.—At the time of the first x-ray report of obstruction at the rectosigmoid junction, the pregnancy itself as an etiologic factor did not enter into the differential diagnosis. It was then the belief of the x-ray department, as well as of the surgical staff, that pregnancy per se did not cause obstruction. It was thought that the most likely cause

flooding of the system with colon bacillus resulting in pyelitis (in 8 out of 9 cases the organisms recovered from the urine were colon bacilli). The probability that this atonia is due to some disturbance of innervation is further strengthened by the fact that in two cases^{29, 32} in which a cesarean section was done to relieve the obstruction due to the pregnancy, a subsequent hysterectomy had to be performed because of hemorrhage resulting from failure of the uterine muscle to contract.

The mortality figures in Tables I, II, and III demonstrate that therapy in reported cases has not been very successful. Case histories show that probably the most important factor in maintaining this high mortality rate has been delay in adequate treatment. Mikulicz-Radecki³ attributes the drop in his statistics to 39 per cent from 54 per cent in Ludwig's² to more prompt consultation with a surgeon. This mortality rate has still further been improved, so that at present it is 21 per cent. If one is alarmed at the high maternal death rate, there is still further cause for alarm in the higher fetal death rate, which the earlier authors said varied between 66.6 per cent and 75 per cent. Unfortunately, the same degree of improvement is not shown in later years as in the maternal mortality rate, so that in 62 cases in our series in which the outcome as to child is mentioned only 31 or 50 per cent of the children survived.

Delay in treatment is much more likely to occur in ileus accompanied by pregnancy than in ileus in a nonpregnant person. Many of the cardinal symptoms of obstruction, with no pathologic significance, are found during a normal gestation. Constipation is the rule in the female, and this is more true during pregnancy. Furthermore, the nausea and vomiting of early pregnancy is also a confusing factor in the first four months, but fortunately very few cases of obstruction occur at this time. A differentiating feature between nausea and vomiting of early pregnancy and that of obstruction is the fact that the abdomen is sunken and not distended in the former. Later, during labor, one might readily mistake the crampy, colicky pain of an intestinal obstruction for normal labor pains. There are many reasons for the delay, though these reasons should not excuse it, because if the possibility of obstruction is considered, the differential diagnosis can be made.

Once the diagnosis of obstruction in pregnancy has been made, it must be decided most promptly whether the obstruction is due to pregnancy itself or to some other factor. The following facts should be borne in mind in making the differentiation. Obstruction due to pregnancy is low in the intestinal tract and is simply an occlusion. The symptoms, therefore, develop slowly and often when first seen the patient simply complains of failure to have had an adequate evacuation for four or five days. Distention quite frequently dominates the picture. This state of affairs is in contrast to volvulus or strangulation due to adhesions, when severe agonizing constant pain accompanied by shock is the outstanding finding. The x-ray, which is invaluable in helping to make the differentiation, shows gas in the large intestine and later also

Peristalsis was hyperactive. Uterus was about the size of a four months' pregnancy. After a diagnosis of intestinal obstruction was made, she was given an x-ray examination to confirm the opinion and determine the point of obstruction if possible. By x-ray there was thought to be an obstacle at the region of the junction of the rectum and sigmoid. By changing the position of the patient on the table, barium passed into the remainder of the colon. The rectum and sigmoid appeared to be displaced as though they were riding over a mass. Following the suggestion of Dr. Pendergrass, the patient was given a soapsuds enema while in the knee-chest position. This was very effectual for feces and flatus and, in addition, relieved her of all her symptoms. She was kept under observation for two days and then discharged. She was delivered at term of a full-term living child. Colon by barium enema eight months later was reported as negative for any lesion.

CASE 3.—D. C., from the service of Dr. J. Vernon Ellison, Delaware County Hospital, white primipara, aged twenty-six years. Last period was on Oct. 20, 1935. During early pregnancy she was confined to bed with nausea and vomiting which, however, subsided in December. She was admitted to the hospital on April 3, 1936, with pain in her right lower abdomen. She had been nauseated and vomited four times the day of admission. In addition to this her bowels had not moved. The only other symptom of interest was burning on urination. Physical examination showed an adult female, not acutely ill, apparently six months pregnant, uterus at umbilicus, temperature 99°, pulse 82, respiration 20, blood pressure 110/64. The finding of tenderness over McBurney's point and spasm of the right lower rectus plus a leucocyte count of 13,800 with 77 per cent neutrophils suggested a diagnosis of acute appendicitis, which was confirmed at operation. Her nausea and vomiting did not subside, however, and abdominal distention appeared. Vomiting increased in severity. An enema returned colored water, but did not relieve patient's symptoms. An x-ray examination on April 9, six days after appendectomy, was reported as follows: "A scout film shows marked distention of the large intestine and moderate distention of the small intestine. These organs are displaced in the usual manner due to a large gravid uterus, which is deflected somewhat toward the left side. The air in the colon diminishes and ends just above the brim of the pelvis. Barium enema easily filled the rectum and sigmoid to the level of the pelvic brim. There was slight delay at this point, then the barium passed beyond into the distended descending colon. With the patient lying on her back there is a pressure defect on the sigmoid at the pelvic brim. There is no evidence of any organic lesion at this point."

The patient was too ill and too distended to be placed in the knee-chest position. Therefore an enema was given with the patient lying on her right side and abdomen, and the foot of the bed elevated about eighteen inches. This resulted in expulsion of gas and barium. Distention subsided and vomiting became much less pronounced, and it also stopped shortly. The patient was discharged from the hospital April 17, with pregnancy uninterrupted. Progress of pregnancy uneventful to date, June 7, 1936.

Discussion.—Cases 2 and 3 illustrate the value of change of position to relieve pressure of the pregnant uterus on the sigmoid. This plan of therapy was thought to be original with the writers until it was found that Fleischhauer⁵ mentions two successful cases and gives credit to Texiere as being the first to have suggested the idea. Halter²² and Graff²¹ also advise the knee-elbow position, but fail to mention any results obtained. Kemkes²⁸ reports an unsuccessful case; however, at laparotomy a ruptured uterus was found, with abdominal child occluding the colon at the hepatic flexure. Another interesting case which would

for the obstruction was an annular neoplasm of the rectosigmoid junction. Because of the marked distention and the poor condition of the patient, it was deemed homicidal to attempt to attack the point of obstruction, and therefore a cecostomy was done with the hope of preparing the patient for a resection of the malignant growth at a later date. Following the cecostomy, the discussion arose as to which of the following three was the proper procedure: (1) to allow pregnancy to go to term and after delivery to attempt radical surgery, (2) to do a laparotomy as soon as condition warranted and ignore the pregnancy, (3) to do a therapeutic abortion followed by laparotomy. The cecostomy did not function sufficiently well to warrant the first procedure. In addition, there was fear of metastasis (as carcinoma was thought to be the cause of obstruction) while we waited four months for the normal end of gestation. The size of the uterus would have made the second plan exceedingly difficult technically. Besides increasing the risk to the mother, it was felt that probably the fetus would be lost by abortion as a result of the surgical intervention. Therefore it was decided to follow the third plan of attack as outlined above.

The question might be asked as to how this diagnosis could have been made earlier and thus the life of the fetus saved. The knowledge that pregnancy sometimes causes obstruction would certainly have aided. Dr. Pendergrass, the roentgenologist, then suggested that if another such case would arise, it might be worth while to attempt an enema in the knee-chest position, in this way releasing the obstructed bowel from the pressure of the pregnant uterus. Keeping this in mind, it was our good fortune to be presented with a somewhat similar case nine months later and still another a year after that.

CASE 2.—E. L., aged twenty-two, primipara, gave a history of previous appendectomy. Catamenia were normal. Last period occurred July 20, 1934. There was slight nausea and vomiting in the afternoon during the early months of pregnancy, but this had ceased two weeks before admission. At 7 A.M., November 2, 1934, the day before admission, the patient got out of bed and became nauseated and vomited. This was accompanied by intermittent gripping pains in the epigastrium. Upon return to bed she felt relieved. She repeated this several times during the morning. Six hours after onset, following an attempt to eat milk toast, her symptoms became more severe in spite of maintaining the supine position. Singultus began. The pain increased in severity. Vomitus changed from pure gastric contents and became tinged with green. Her family physician was promptly called. He advised an enema and gave her a hypodermic. This relieved the pain considerably. Enema was returned with small amount of feces. Pain and vomiting returned and enema was repeated. Again, this was only slightly effectual. Another enema was given which also did not relieve the patient. Because of the persistence of nausea, vomiting, and intermittent pain, she was referred to the hospital, eighteen hours after onset, with a tentative diagnosis of intestinal obstruction. Findings on admission: a young female, apparently acutely ill with abdominal pain, temperature 99° F., pulse 124, respiration 32, blood pressure 120/68, white blood cells 11,700. The lips were dry, and the patient was apparently dehydrated. Otherwise, the findings were negative except for those of the abdomen, which was distended, revealing also visible peristalsis. There was some tenderness in the epigastrium.

itself is a rare cause for the obstruction, it is not as infrequent as one might suspect from consulting standard textbooks on surgery and obstetrics.

Three additional cases are reported in which probably the pregnancy per se was the etiologic factor.

A conservative method of treatment (change of position) has been advanced and precautions discussed which should be followed.

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*Number of cases reported are indicated in parentheses after each reference.

tend to support this plan of treatment is that of Hornung.⁶ This patient developed obstruction during labor and intervention was postponed with the hope that the ileus would be relieved with the emptying of the uterus. After observing the patient for three hours after delivery and failing to note satisfactory improvement, a laparotomy was decided upon. At operation, distention of both large and small bowel was found. The distended large loop having been traced into the pelvis, the uterus had to be lifted. There was prompt evacuation of both flatus and feces on the table, with collapse of the distended bowel. Following the laparotomy, she made an uneventful convalescence. Steinitz⁴⁶ reports a similar case in which the obstruction corrected itself during preparation of the patient for a cesarean section. One might assume that these two cases could have been successfully treated by the knee-chest position.

The question, whether to terminate the pregnancy by the vaginal route or do a laparotomy, arose in past discussions. This should no longer be a point of debate. If the obstruction is not relieved by a high enema with change of position, a laparotomy is clearly indicated. If after the laparotomy, the obstruction is found to be due to the pregnancy itself, and the child is viable, the indication for a cesarean section is a clear one. If the child is not viable, it still would seem to be the safer course to empty the uterus, though possibly one might be able to correct the point of pressure by manipulation with the hand in the peritoneal cavity. Furthermore, if one had proved that there was no other cause for obstruction, it would be perfectly safe to empty the uterus by the vaginal route if symptoms did not subside following laparotomy. At operation, Sennewald^{43, 44} suggests the insertion of a long rectal tube past the point of obstruction, with the aid of intraabdominal manipulation. This procedure seems to be of special value in cases in which the child is not viable and one hesitates to empty the uterus.

Any form of treatment except immediate laparotomy meets the criticism of the danger of delay, especially if the obstruction later proves to be due to volvulus or adhesions. This danger can be minimized if one bears in mind the previously mentioned differential points in symptomatology and the great value of the x-ray. Furthermore, preparation for laparotomy should be made while conservative measures are being tried, or as Dietrich⁷ stated, "mit dem Messer in der Hand." The old axiom that an effectual enema is one that relieves the patient of his symptoms rather than one effectual for gas or feces will further protect the surgeon from needless delay.

SUMMARY

A review of the literature on intestinal obstruction complicating pregnancy emphasizes (1) the difficulty of diagnosis, (2) the high maternal and still higher fetal mortality, and (3) that though pregnancy

ligated, and the mesentery was cut so as to eliminate the possibility of a collateral venous return, the arterial supply being left intact. The blood potassium and blood density were followed at two-hour intervals. The cat died 15 hours after operation, in a convulsion. *Autopsy*: Black intact loop bathed by reddish peritoneal fluid; the potassium content of the loop was 77.2 mg. per cent.

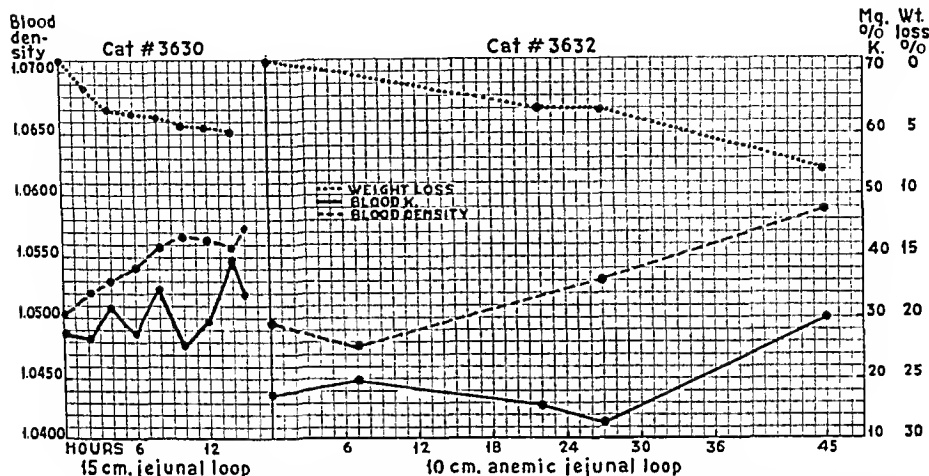


Fig. 1.—Cat 3630. Fifteen-centimeter jejunal loop obstructed between tapes. Survival 15 hours. Graph indicates decrease in weight, and rise in blood density. Two-hourly determinations of potassium show fluctuation above normal, with a 100 per cent increase before death. Loop contents: 77.2 mg. per cent potassium.

Cat 3635. Ten-centimeter anemic loop of jejunum between tapes. Survival 48 hours. Weight loss was 8.7 per cent. Fall in potassium to below normal, with a 50 per cent rise above normal during the last day of life. Rise in blood density preceded rise in potassium.

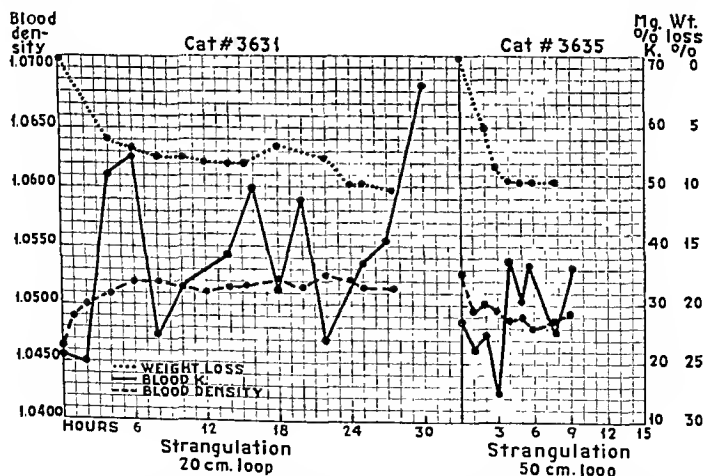


Fig. 2.—Cat 3631. Twenty-centimeter loop of jejunum strangulated by tape. Survival 30 hours. Progressive weight loss of 10.5 per cent. Blood density increased during first 6 hours and remained constant at this level. A 150 per cent increase in potassium during first 6 hours, followed by fluctuations with a rise to 230 per cent above normal during last 8 hours.

Cat 3635. Fifty-centimeter loop of jejunum and ileum strangulated by tape. Survival 9½ hours. Weight loss was 10.5 per cent. Fall in blood density with a slight terminal rise. Sharp fall in blood potassium during first 3 hours, with a mean level of 33.2 mg. per cent, representing a 65 per cent increase above normal during last 6 hours. Peritoneal fluid 63 mg. per cent. Loop contents 131.2 mg. per cent.

POTASSIUM IN ACUTE INTESTINAL OBSTRUCTION

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ACUTE intestinal obstruction and adrenal insufficiency have many features in common.¹ In each, the cause of death has been variously ascribed to dehydration, electrolyte loss, or to an unknown toxin.

A series of researches by Zwemer and Truszkowski²⁻⁵ have demonstrated that "the various known symptoms of corticoadrenal insufficiency may be explained in terms of a disturbance of corticoadrenal-potassium interrelations." In particular, the hyperpotassemia of certain phases of adrenal insufficiency was found to be of the same order as that associated with toxic symptoms in animals subjected to experimental chronic potassium poisoning.

It was therefore felt that the variations in blood potassium following acute intestinal obstruction should be investigated.

EXPERIMENTAL MATERIAL AND METHODS

Eight cats were used in the experiments; in 4 the intestines were obstructed with jejunal loops of various lengths and the remainder had simple obstructions at different levels of the alimentary tract (Table I). Aseptic technique, ether anesthesia, a midabdominal incision, and a minimum amount of handling of the viscera, allowed the animals to recover, with no sign of shock, within an hour of the operation. Cotton tape was used in making the obstruction and silk for closure. There were no complicating wound infections.

Blood potassium was determined by Truszkowski and Zwemer's² method for 0.2 ml. of cat whole blood. Whole blood determinations are permissible in the cat, since the potassium content of cells and plasma is similar and rise and fall together. Blood density was determined by the falling drop method of Barbour and Hamilton.^{6, 7} The values given on the charts and in the protocols represent the means of two or more determinations.

EXPERIMENTAL OBSERVATIONS AND DATA

Group 1.—For the first group of four animals the procedure consisted of obstruction and interference with the vascular supply.

A. A closed 15 cm. jejunal loop was formed in Cat 3630 by tying one tape just below the ligament of Treitz and a second tape 15 cm. lower. The veins were

Autopsy: Peritoneal fluid was abundant and reddish in color; the ligatured loop was distended and filled with reddish, foul fluid; the color of the mesentery and intestine was greenish black; the small intestine below the obstruction was collapsed; the stomach and duodenum were markedly distended; there was no peritonitis.

In Cat 3635, strangulation of a 50 cm. loop of jejunum and ileum was effected by means of a tape passed around the base of the mesentery, permitting arterial inflow but preventing venous return. Blood potassium and density were followed hourly. The latter fell rapidly during the first six hours, with a terminal small concentration. The potassium fell from an initial value of 27.7 mg. per cent to below normal by the third hour; it then rose to 37.6 mg. per cent and fluctuated

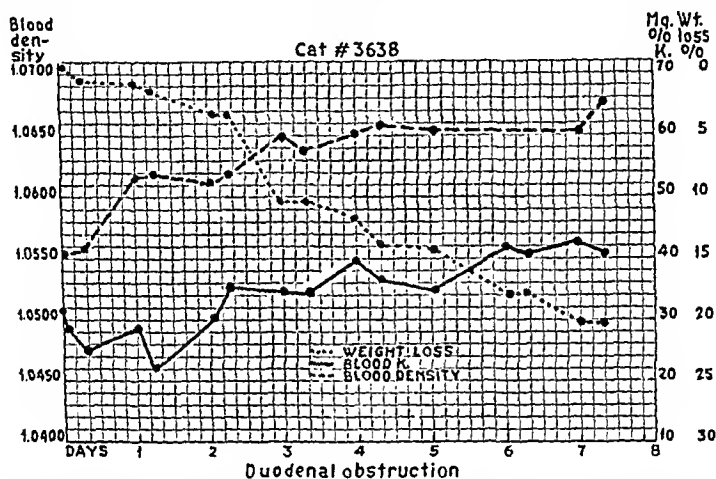


Fig. 4.—Cat 3638. Duodenal obstruction. Killed at 176 hours, as it was moribund. Weight loss was 21.2 per cent. Gradual rise in density during first 3 days. This increase was maintained until the end. Fall in potassium preceded a progressive fluctuating rise to levels over 100 per cent above normal during last 36 hours.

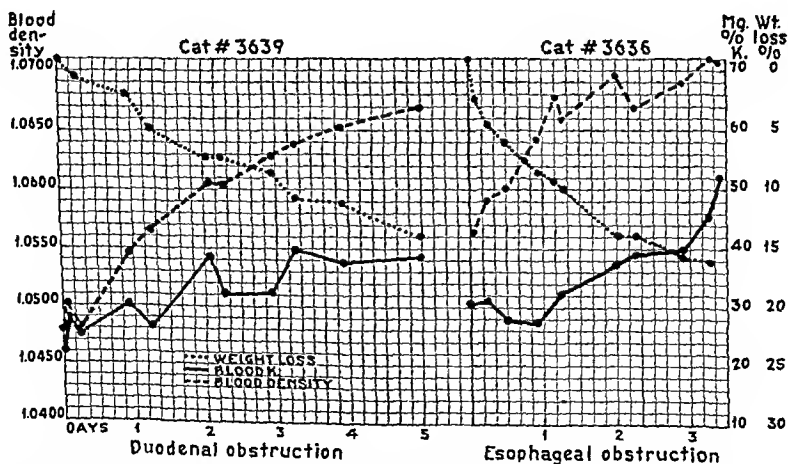


Fig. 5.—Cat 3639. Duodenal obstruction by tape below ampulla of Vater. Survival 128 hours. Weight loss was 15 per cent. Sustained rise in blood density. Fluctuating increase in blood potassium to levels 100 per cent above normal during the last 48 hours. Vomitus 254 mg. per cent. Blood potassium at this time 38.5 mg. per cent. Cat 3636. Esophageal obstruction at cardiac juncture. Survival 80 hours. Weight loss was 17 per cent. Rapid increase in blood density. Fall in potassium followed by a sustained rise to 160 per cent above normal.

TABLE I
TYPES OF OBSTRUCTION WITH SURVIVAL TIME

1. Strangulation of a 50 cm. loop below the ligament of Treitz. Cat 3635.	9 hr.
2. Closed 15 cm. jejunal loop. Veins ligated. Mesentery cut to prevent collateral return. Arteries intact. Cat 3630.	15 hr.
3. Strangulation of 20 cm. jejunal loop below the ligament of Treitz. Cat 3631.	30 hr.
4. Closed 10 cm. jejunal loop with arteries and veins ligated. Lymphatics also blocked. "Anemic loop." Cat 3632.	48 hr.
5. Simple obstruction of esophagus at cardiac juncture. Cat 3636.	80 hr.
6. Simple obstruction of duodenum 3 cm. below ampulla of Vater. Cat 3639.	124 hr.
7. Simple obstruction of duodenum 2.5 cm. below ampulla of Vater. Cat 3638.	*176 hr.
8. Simple obstruction of transverse colon. Cat 3634.	†23rd day

*Killed at 176 hours, as cat was moribund.

†Abdomen opened on twenty-third day. Animal killed.

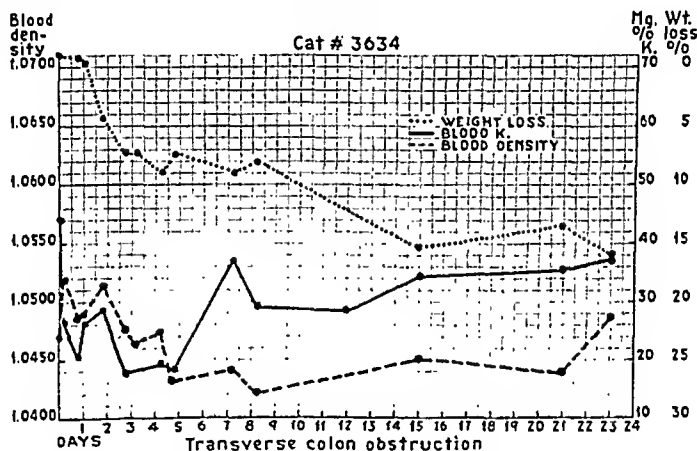


FIG. 3.—Cat 3634. Obstruction of transverse colon with tape. Abdomen reopened on twenty-third day, showing colon partially obstructed. This coincided with stools after the fourth day. Progressive decrease in weight, with a 17 per cent loss. Concentration of blood with subsequent dilution and a final increase in blood density. Blood potassium fell during first 5 days with a rise on the seventh day, followed by a level 75 per cent above normal.

In another cat (3632), a 10 cm. jejunal loop was formed between tapes as in the first experiment. The arteries, veins, and lymphatics were ligated, thus forming an anemic loop (see protocol). The survival time was 48 hours. The rise in blood density occurred sooner than the final rise in blood potassium. *Autopsy:* The loop was found to be black, not ruptured; the peritoneal fluid was reddish and abundant; the lungs were pink and collapsed; the heart was in diastole.

B. The two other animals of this group had strangulation of jejunal and upper ileal loops. In the first (3631) a 20 cm. jejunal loop was formed by ligating the base of the mesentery with tape. The constriction permitted arterial flow but not venous return. Blood potassium and density were followed hourly, and fluctuations in the former were marked. The blood density reached its peak in 6 hours and remained at this level until death. The weight fall was progressive except for one rise after giving the animal water. The terminal rise of potassium to 66 mg. per cent was the highest in this first group. Cat survived 39 hours.

blood for forty-eight hours, with a subsequent dilution. This was paralleled by a rise and fall in potassium. On the fourth day after the operation the general condition of the cat suddenly improved, which was coincident with the passage of a stool, signifying reestablishment of the continuity of the alimentary tract.

B. Cat 3638 had its duodenum obstructed 2.5 cm. below the ampulla by means of a tape. Potassium and density were determined twice daily. The train of symptoms developed slowly. Vomiting occurred only twice during the first forty-eight hours. Prostration was marked during the last two days, and moderate bleeding from the buccal cavity was observed. The animal was killed after 176 hours, as it was moribund. The rises in potassium and density were practically constant. *Autopsy:* A greatly dilated stomach and duodenum; collapsed small intestine; there was no peritoneal fluid nor sign of inflammation; the lungs were pink, collapsed, and free from consolidation; the heart was in diastole; weight loss 21.2 per cent.

The duodenum was obstructed 3 cm. below the ampulla of Vater in Cat 3639, as in the previous cat. Blood potassium and density were followed twice daily. The rises in potassium and density were practically parallel. Vomiting occurred more frequently than in Cat 3638. A sample of vomitus taken 120 hours after ligation contained 254 mg. per cent of potassium, at a time when the blood potassium was 38.5 mg. per cent. Survival 130 hours. Weight loss 14.9 per cent.

C. In Cat 3636, the esophagus was ligated through an upper midline abdominal incision at its juncture with the cardia. The postoperative course was punctuated with repeated vomiting of frothy fluid. The rise in potassium was the most constant in this experiment, and the blood density reached its highest figure. The

PROTOCOL 2

Cat 3632. Female. Weight, 3.572 Kilos. Closed Jejunal Loop, 10 cm. With Arteries and Veins Tied. "Anemic Necrosis."

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DENSITY	BLOOD K MG. %
Aug. 8	12:30 P.M.	0	Good; blood from ear	-	1.0484	-
9	12:30 P.M.	0	Good; blood from ear	-	1.0479	-
10	1:00 P.M.		Active and healthy; blood sample from ear	-	1.0496	17.3
	1:30 P.M.		Obstructed by tapes under ether			
	1:45 P.M.	15 min.	Blood from ear		1.0500	-
	5:05 P.M.		Breathing rapidly, 120; vomited; refuses fluid			
11	8:30 P.M.	7 hr.	Blood sample from ear		1.0477	19.5
	8:00 A.M.		Lies on side; refuses food; respirations slower, 50			
	11:15 A.M.	22 hr.	Blood sample from ear	3.9	-	15.9
	4:30 P.M.	27 hr.	Hind legs weak; tumor mass felt in abdomen; vomited; blood sample from ear	4.0	1.0533	12.5
	6:00 P.M.		Vomited blackish fluid			
	8:45 P.M.		Urimated; resp. 74			
12	9:00 A.M.	45 hr.	Unable to stand; vomited during night; resp. 72	8.7	1.0587	29.6
	12:15 P.M.	47 hr.	Lying stretched out; body cold; unable to raise head; vomited			
	4:15 P.M.		Found dead			

Autopsy: Loop black; not ruptured; peritoneal fluid abundant and reddish in color. Stomach dilated. Intestines collapsed; large bowel filled with hard feces. Thoracic cage contained no fluid; lungs collapsed, pink. Heart in diastole. Kidneys pale, tense, and swollen. Bladder distended. Adrenals soft; tan color.

in this high range until death. The course of symptoms was rapid, with profuse vomiting, prostration, air hunger, and a terminal generalized convulsion just before death. The survival time was 9 hours. Peritoneal fluid removed immediately after death had a potassium content of 63 mg. per cent, while that of the contents of the obstructed loop was 131 mg. per cent. *Autopsy*: Peritoneal cavity contained a greenish red fluid; the ligated loop was distended and filled with a foul reddish black fluid; the intestines below the obstruction were contracted; proximal duodenum and stomach were dilated; the lungs were collapsed, pink, and showed no consolidation; the heart was in diastole and practically empty of blood.

Group II includes cats with *simple obstruction* at different levels.

4. The transverse colon of Cat 3634 was obstructed by ligature with tape. Blood potassium and density were determined twice daily for 4 days; daily for 4 days; and then every fourth day until the abdomen was reopened on the twenty-third day. Inspection of the colon showed hypertrophy and dilatation of the proximal part. The patency of the bowel had partly reestablished itself, permitting the introduction of a probe at the site of obstruction. There was a concentration of the

PROTOCOL 1

Cat 3630. Male. Weight, 3.543 Kilos. Closed Jejunal Loop, 15 cm., With Veins Ligated and Mesentery Cut so as to Prevent Collateral Venous Circulation. Arteries Intact.

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DENSITY	BLOOD K MG. %
Aug. 15	1:00 P.M.	0	Good	-	1.0486	-
16	10:00 A.M.	0	Good	-	1.0524	-
17	1:00 P.M.	0	Good	-	1.0502	27.5
	2:10 P.M.		Obstructed under ether	2.4	1.0521	26.3
	4:25 P.M.	2 hr.	Recovered; vomited twice			
	6:20 P.M.	4 hr.	Vomited; listless; blood sample from ear	3.0	1.0528	31.8
	8:30 P.M.	6 hr.	Sitting with head down; wound bulging; blood sample from ear	3.2	1.0542	27.6
	10:30 P.M.	8 hr.	Crouching; hind leg weakness; sample of blood from ear	3.6	1.0558	32.3
18	12:30 A.M.	10 hr.	Walks with unsteady gait; diarrhea; blood sample from ear	4.1	1.0565	25.0
	2:30 A.M.	12 hr.	Lying down; dry skin; hind leg weakness; peripheral blood very thick and scanty; heart blood had to be taken; water given	4.4	1.0564	28.7
	4:30 A.M.	14 hr.	Temp. 96° rectal; resp. 120; lying stretched out; does not respond to sudden loud noise; blood samples from ear and heart	4.8	1.0558	30.3
	5:15 A.M.	15 hr.	Grunting respiration; twitching of legs; unsteady gait; slight convulsion; peripheral blood not obtained; heart blood	4.8	1.0573	33.8
	5:18 A.M.		Dead. Loop contents at autopsy. 77.2 mg. % K			

Autopsy: Loop black, not ruptured; reddish peritoneal fluid; contents of loop brownish red. Lungs collapsed. Heart in diastole. Bladder distended.

in this high range until death. The course of symptoms was rapid, with profuse vomiting, prostration, air hunger, and a terminal generalized convulsion just before death. The survival time was 9 hours. Peritoneal fluid removed immediately after death had a potassium content of 63 mg. per cent, while that of the contents of the obstructed loop was 131 mg. per cent. *Autopsy*: Peritoneal cavity contained a greenish red fluid; the ligated loop was distended and filled with a foul reddish black fluid; the intestines below the obstruction were contracted; proximal duodenum and stomach were dilated; the lungs were collapsed, pink, and showed no consolidation; the heart was in diastole and practically empty of blood.

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17	1:00 P.M.	0	Good	-	1.0502	27.5
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	4:25 P.M.	2 hr.	Recovered; vomited twice			
	6:20 P.M.	4 hr.	Vomited; listless; blood sample from ear	3.0	1.0528	31.8
	8:30 P.M.	6 hr.	Sitting with head down; wound bulging; blood sample from ear	3.2	1.0542	27.6
	10:30 P.M.	8 hr.	Crouching; hind leg weakness; sample of blood from ear	3.6	1.0558	32.3
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	5:18 A.M.		Dead. Loop contents at autopsy, 77.2 mg. % K			

Autopsy: Loop black, not ruptured; reddish peritoneal fluid; contents of loop brownish red. Lungs collapsed. Heart in diastole. Bladder distended.

DISCUSSION

The results described in the present paper are in conformity with those of Murphy and Vincent⁸ and others,^{*} who found that animals with simple obstruction lived longer than those with interference of the vascular supply, and that the survival time in the latter varied inversely with the length of the occluded loop. In simple obstruction in experimental animals and in human beings, the higher the location of the lesion in the alimentary tract, the more rapid is the lethal outcome.⁹

Amussat¹⁰ was the first to suggest that intestinal obstruction led to a general toxemia, and many subsequent workers have produced evidence in support of this view, particularly when strangulation is a complicating factor. The theories regarding the chemical nature of toxic substances are too diversified to be discussed in detail. One

PROTOCOL 4

Cat 3635. Male. Weight, 2.779 Kilos. Strangulation of 50 cm. Loop of Jejunum and Ileum

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DEN-SITY	BLOOD K MG.%
Sept. 2	10:00 A.M.	0		2.779	1.0526	27.7
	1:10 P.M.		Operation ended; duration 15 min.			
	2:10 P.M.	1 hr.	Vomited salmon; blood from ear		1.0492	22.2
	3:25 P.M.	2 hr.	Vomited several times; blood sample from ear	6.1	1.0501	25.5
	4:25 P.M.	3 hr.	Body cold; prostrated; vomited much undigested food; blood sample from ear	9.3	1.0495	17.3
	5:24 P.M.	4 hr.	Hard distended loops felt; prostrated; still vomiting	10.2	1.0486	37.6
	6:25 P.M.	5 hr.	Bulging coils of intestine felt; prostrated; cold	10.2	1.0489	30.2
	6:55 P.M.	6 hr.	Lying on side; quiet; blood sample from ear	10.2	1.0479	36.6
	8:55 P.M.	8 hr.	Body cold; air hunger	10.5	1.0485	25.0
	10:20 P.M.	9 hr.	Air hunger marked; heart blood taken, as peripheral blood scanty		1.0492	36.4
	10:30 P.M.		Died after generalized convulsion			
			Autopsy done at death. Peritoneal fluid			63.0
			Contents of loop			131.2

Autopsy: The peritoneal fluid was abundant and reddish in color; ligatured loops distended and filled with reddish foul fluid; diameter of loop 2 cm. Mesentery and intestine were greenish black. Loop not ruptured. No peritonitis. Small intestine below obstruction collapsed. Stomach and duodenum markedly distended. Spleen shrunken. Liver had nutmeg appearance. Kidneys pale, large, and soft. Adrenals pale. Lungs collapsed, pink, and free from consolidation. Heart in diastole. Bladder distended.

*A more complete discussion and bibliography are given by Cooper, H. S. F.: Cause of Death in High Obstruction, Arch. Surg. 17: 918, 1928.
 Melver, M. A.: Acute Intestinal Obstruction, New York, 1934, Paul B. Hoeber, Inc.

weight loss was 17.1 per cent. Death in coma after 80 hours. *Autopsy:* No evidence of peritonitis; stomach, small intestine, and large intestine were collapsed; the obstruction was complete at the cardiac end of stomach; esophagus dilated; lungs pink and collapsed, no consolidation.

In these experiments, intestinal obstruction was associated with a rise in blood potassium to levels which have been shown to be toxic.⁵ In the animals with strangulation the high levels were reached within a few hours. The two cats with duodenal obstruction evidenced a steady rise in potassium. The animal with esophageal obstruction, however, gave the most consistent and sustained rise. There was hemoconcentration in all the experiments save the one in which a 50 cm. loop of the upper intestine had been strangulated. This may be ascribed to considerable loss of blood into the loop. The greatest increase in blood density was manifested in esophageal obstruction.

PROTOCOL 3

Cat 3631. Male. Weight, 3.686 Kilos. Strangulation of 20 cm. Loop of Jejunum and Upper Ileum

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DENSITY	BLOOD K MG. %
Aug.						
15	10:00 A.M.	0	Good		1.0482	19.1
16	9:30 A.M.	0	Good; blood sample from ear		1.0488	
17	1:00 P.M.	0	Blood sample from ear		1.0461	21.2
<i>Operation ended 2:30 P.M. Duration 15 min.</i>						
	3:30 P.M.	1 hr.	Vomited once, on coming out of ether and again 1 hr. later		1.0492	
	4:30 P.M.	2 hr.	Blood sample from ear		1.0500	20.1
	6:40 P.M.	4 hr.	Vomited; restless; wound bulging	7.0	1.0509	52.3
	8:30 P.M.	6 hr.	Prostrated; hind leg weakness; blood sample from ear	7.7	1.0522	55.8
	10:30 P.M.	8 hr.	Prostrated; abdomen bulging	8.1	1.0519	24.2
18	12:50 A.M.	10½ hr.	Abdomen now tightly distended; blood sample from ear	8.5	1.0516	33.2
	2:45 A.M.	12 hr.	Hind leg weakness; blood sample from ear	8.9	1.0511	
	4:30 A.M.	14 hr.	Rectal temp. 100.1°; resp. 48	8.9	1.0515	38.6
	6:00 A.M.	15 hr.	Prostrated; water given; drank greedily	9.0	1.0515	49.7
	8:30 A.M.	18 hr.	Abdomen tight; wound wet; legs weak; drinks water	7.3	1.0522	32.5
	10:30 A.M.	20 hr.	Lies on side		1.0514	46.9
	12:40 P.M.	22 hr.	Abdomen tight; legs weak	8.5	1.0524	22.0
	3:00 P.M.	24 hr.	Body cold	10.9	1.0520	
	3:30 P.M.	25 hr.	Unable to get peripheral blood; heart blood	10.9	1.0515	36.5
	6:15 P.M.	28 hr.	No peripheral blood; heart blood	11.1	1.0514	40.9
	9:30 P.M.	30 hr.	Dead. Heart blood. Autopsy immediately			66.6

Autopsy: Peritoneal cavity filled with reddish fluid; strangulated loop distended, reddish black, and filled with foul reddish brown fluid. Loop not ruptured. Intestine below obstruction collapsed. Colon contracted and filled with solid fecal material. Stomach and duodenum dilated. Liver had nutmeg appearance and was soft. Spleen leathery. Kidneys brownish yellow and soft. Adrenals pale. Lungs collapsed and pink; free from consolidation. Heart in diastole. Urinary bladder distended.

to loss of digestive secretions, a conception elaborated upon by numerous subsequent workers. There exists, however, a twofold objection to the conclusions of these authors. First, in rabbits which do not vomit, the continued removal of accumulated secretions in the stomach from these animals with jejunal obstruction and the administration of sodium chloride practically double the survival period.¹⁷ Second, in animals with esophageal obstruction, the same clinical course and the same biochemical findings are present in an even more striking form than in high intestinal obstruction. Workers who explain death in simple obstruction on a water or electrolyte depletion basis admit,

PROTOCOL 6

Cat 3638. Male. Weight, 4.818 Kilos. Obstruction of Duodenum 2.5 cm. Below the Ampulla of Vater

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DEN- SITY	BLOOD K MG. %
Sept. 21	10:15 A.M.	0	Strong, healthy; blood sample obtained after much struggling		1.0554	31.7
	10:30 A.M.		Operation			
	12 NOON	1½ hr.	Recovered; still resists; urinated	0.6	1.0553	28.5
	6:15 P.M.	8 hr.	Blood sample from ear; refused milk and water	1.4	1.0557	25.5
	7:15 P.M.		Stool			
	12 MID-NIGHT		Lying stretched out; quiet			
22	10:50 A.M.	24 hr.	Resisted taking blood; refuses salmon, milk, and water	1.7	1.0615	28.7
	5:50 P.M.	30 hr.	Still resists when blood is drawn; abdomen distended; violent vomiting.	2.4	1.0617	21.8
	8:00 P.M.		Cage drenched with brownish fluid			
23	12:30 P.M.	50 hr.	Blood sample from ear	4.1	1.0611	30.3
	5:45 P.M.	55 hr.	Blood sample from ear; quiet	4.1	1.0617	35.2
24	8:45 A.M.		Vomited brownish fluid			
	10:20 A.M.	72 hr.	Blood sample from ear; refuses milk and water	11.2	1.0651	34.5
	5:20 P.M.	79 hr.	Blood from ear; hind leg weakness	11.2	1.0638	34.3
25	7:00 A.M.		Vomited during night			
	10:20 A.M.	96 hr.	Blood from ear; refused salmon	12.7	1.0652	39.7
	2:00 P.M.		Hind leg weakness; urinated			
	6:45 P.M.	104 hr.	Blood from ear; drank water	14.7	1.0659	36.7
26	6:30 A.M.		Lying stretched out and limp			
	11:20 A.M.	121 hr.	Abdomen distended; blood from ear	15.3	1.0654	34.8
27	11:30 A.M.	145 hr.	Blood taken from ear	18.8		42.0
	6:00 P.M.	151 hr.	Blood taken from ear	18.8		40.9
28	11:15 A.M.	169 hr.	Blood from ear; tongue bloody	21.2	1.0653	42.6
	6:15 P.M.	176 hr.	Vomited brownish fluid; blood taken from heart; animal killed, as it was moribund	21.2	1.0676	41.0

Autopsy: Stomach greatly dilated. Small intestine collapsed. No peritoneal fluid. Lungs collapsed. Heart in diastole. Kidneys tense and swollen. Adrenals pale. Urinary bladder distended.

selioli, headed by von Albeek,¹¹ holds that the toxin is diffusible, while Kukula,¹² on the other hand, stated that the Chamberland filter removed it. Murphy and Vincent concluded that the toxic substance is destroyed by boiling, is insoluble in water, and will not pass a Berkefeld filter. In their investigation of toxic fluid from the peritoneal cavity, Aird and Henderson¹³ found at least two distinct toxic substances: one a complex protein of the euglobulin type, probably of bacterial origin, and the other, a dialyzable substance of the nature of histamine. The apparent histamine content of the transudate, tested pharmacologically on rat's uterus and on guinea pig's ileum, increased steadily in the first twenty-four hours. Slome and Knight¹⁴ excluded the possibility of the latter substance's being either histamine or acetylcholine, but confirmed the finding that the peritoneal fluid in cases of strangulation was, at the end of twenty-four hours, definitely toxic. It is of interest that Van Beuren¹⁵ demonstrated that the normal intestinal contents and mucosa were also toxic to laboratory animals.

Hartwell and Hoguet¹⁶ questioned the idea of toxemia and were first to formulate a definite theory that death from obstruction was due

PROTOCOL 5

Cat 3634. Male. Weight, 3.2 Kilos. Obstruction of Transverse Colon

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DEN- SITY	BLOOD K MG. %
July 15 Aug.			Fasting sample from ear			21.2
10	1:50 P.M.	0	Blood sample from ear after a meal		1.0470	42.0
<i>2:07 P.M. Obstruction of transverse colon ended</i>						
10	2:15 P.M.	15 min.	Not recovered		1.0518	
	8:40 P.M.	6½ hr.	Blood sample from ear			26.3
11	11:10 A.M.	21 hr.	Drank water and milk	0.4	1.0485	20.4
	4:45 P.M.	26½ hr.	Urinated; blood from ear	0.6	1.0486	26.2
	6:10 P.M.	28 hr.	Vomited brownish fluid		1.0488	
12	9:00 A.M.	43 hr.	Refuses water and milk	5.4	1.0513	28.3
	5:15 P.M.	51 hr.	Refuses water and milk		1.0485	
13	9:15 A.M.	67 hr.	Hind leg weakness apparent	8.2	1.0174	17.8
	5:10 P.M.	75 hr.	Refuses food and water		1.0563	
14	9:00 A.M.	105 hr.	Drank milk	10.0	1.0475	19.4
	12:30 P.M.	108 hr.	Passed a stool; condition during afternoon changed			
15	9:00 A.M.	129 hr.	Very alert; eats	8.2	1.0134	18.3
17	9:00 A.M.	7 days	Vomited several times; diarrhea	10.0	1.0112	36.9
18	9:30 A.M.	8 days	Eats	8.9	1.0120	29.0
22	9:30 A.M.	12 days	Active; very thin			28.5
25	9:30 A.M.	15 days	Stools watery, yellow	16.3	1.0152	31.6
31	9:30 A.M.	21 days	Eats; active; stools	14.5	1.0140	35.6
Sept. 2	12:05 P.M.	23 days	Thin and scrawny	17.0	1.0186	37.3

The abdomen was opened under anesthesia. Peritoneal cavity dry; several omental adhesions about site of ligature. Proximal cecum hypertrophied and dilated 2 cm. in diameter. The obstruction was 10 cm. caudad from the ileocecal valve. On opening the bowel, a probe could be passed through the partial occlusion.

the loop, tissue necrosis, bacterial toxins, all contribute to the rapid demise of the animal, probably by effecting an earlier and sustained rise in blood potassium. This would involve the potassium-raising effect of dehydration, blood loss,¹⁹⁻²¹ and the release of potassium from injured tissue cells. Toxins of bacterial origin, such as histamine, may also contribute to this rise in potassium, since it has been shown that injections of histamine will raise blood potassium.²² The excess of potassium entering the blood stream might thus be satisfactorily accounted for as arising from the above-enumerated sources.

PROTOCOL 8

Cat 3636. Male. Weight, 3.6 Kilos. Esophageal Obstruction at Cardiac End of Stomach by Tape

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DEN-SITY	BLOOD K MG. %
Sept. 21	10:00 A.M.	0	Condition good		1.0503	30.0
	11:45 A.M.	0	Operation ended (15 min.)			
	12:30 P.M.	45 min.	Vomited frothy fluid		1.0563	20.8
	1:30 P.M.	1½ hr.	Vomited frothy fluid 4 times in last hour; constant licking	3.2	1.0563	
	2:15 P.M.	2½ hr.	Restless; retching; vomited twice	3.2	1.0563	
	5:45 P.M.	6 hr.	Vomited twice; resp. 106	5.5	1.0591	30.8
	11:20 P.M.	11½ hr.	In past 5 hr. vomited twice; resp. varied from 34 to 83; refused milk and water; not so restless	7.1	1.0601	27.7
22	12:10 A.M.		Vomited twice; still restless; drank 4 oz. water			
	1:10 A.M.		Heart rate 106; resp. 40; vomited twice			
	5:40 A.M.	18 hr.	Lying limp in cage	8.9	1.0622	
	10:30 A.M.	22½ hr.	Vomited twice; drank water	9.4	1.0641	27.5
	3:50 P.M.	28 hr.	Vomited twice; refused salmon; drank water and vomited	10.2	1.0678	
23	5:40 P.M.	30 hr.	Vomited once; restless; retching; drinks little; sits with head over bowl; urinated first time since operation	11.0	1.0660	32.2
	5:30 A.M.		Pulse 170; resp. 36			
	8:40 A.M.		Passed urine			
	12:15 P.M.	48½ hr.	Sits with head over bowl; body cold; hind leg weakness	14.9	1.0696	36.9
	5:15 P.M.	53½ hr.	Drinks water	14.9	1.0669	38.5
24	11:20 P.M.		Vomited			
	7:00 A.M.		Hind leg weakness			
	9:50 A.M.	70 hr.	Sits with head over bowl of water; drinks occasionally	16.6	1.0690	39.6
	11:30 A.M.		Vomited; lies stretched out; body cold; difficult to rouse; pulse 120; resp. 14	17.1	1.0713	45.3
	5:15 P.M.	77½ hr.				
	8:15 P.M.	80½ hr.	Died in coma; last blood sample from vena cava		1.0709	52.0

Autopsy: No peritonitis. Stomach, small intestine, and colon contracted. Bladder distended. Liver and spleen shrunken. Kidneys pale and soft. Adrenals pale. On opening the stomach the obstruction at the cardia was found complete. Esophagus dilated. No fluid in thoracic cavity. Lungs collapsed, pink; free from consolidation. Heart in diastole.

however, that a new factor is added to the syndrome when the blood supply is impaired, this being associated with some form of toxemia.

These discordant views may be reconciled on the assumption that the condition is essentially one of *potassium* poisoning. This conclusion is based on our determination of blood potassium during the course of the entire syndrome in both simple and strangulated obstructions. Our experiments reveal toxic levels of blood potassium, which could, in themselves, be responsible for death.

In simple obstruction, the potassium rise can be ascribed to dehydration associated with loss of extracellular, and replacement by intracellular, fluids and electrolytes.¹⁸ In strangulation, however, the picture is complicated by several factors. Obstruction, hemorrhage in

PROTOCOL 7

Cat 3639. Male. Weight, 3,799 Kilos. Simple Duodenal Obstruction 3 cm. Below Ampulla of Vater

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DEN-SITY	BLOOD K MG. %
Sept. 21	9:30 A.M.	0	Good condition		1.0478	21.8
	12:10 P.M.	40 min.	<i>After operation</i> Blood sample from ear		1.0501	28.7
	1:30 P.M.		Recovered; sitting up			
	6:00 P.M.	6 hr., 40 min.	Condition good; refuses milk, salmon, and water	1.5	1.0479	25.2
	12 MID-NIGHT		Lying quietly; no vomiting			
22	7:05 A.M.		Vomited greenish fluid			
	10:20 A.M.	23 hr.	Blood sample from ear	2.9	1.0546	30.5
	11:40 A.M.		Urinated			
	2:40 P.M.		Vomited greenish fluid			
	5:45 P.M.	30½ hr.	Blood sample from ear	5.9	1.0565	26.1
	9:00 P.M.		Vomited greenish fluid			
23	5:30 A.M.		Sitting up; good resp. 72			
	8:40 A.M.		Vomited greenish fluid; drinks water freely			
	12:20 P.M.	49 hr.	Blood sample from ear	8.2	1.0606	38.5
	5:45 P.M.	54 hr.	Blood sample from ear	8.2	1.0604	32.0
	5:50 P.M.		Urinated; lying down with head up			
24	1:00 A.M.		Vomited			
	7:00 A.M.		Vomited between 1 and 7 A.M.			
	10:10 A.M.		Blood sample from ear	9.5	1.0627	32.3
	1:00 P.M.		Hind leg weakness			
	2:00 P.M.		Vomited foul-smelling, yellowish fluid twice			
	5:15 P.M.	78 hr.	Blood sample from ear; sitting all afternoon with head over water; does not drink; urinated; condition poor; body cold	11.9	1.0637	39.7
25	9:50 A.M.	95 hr.	Blood sample from ear	12.1	1.0652	37.5
	6:30 P.M.	103 hr.	Blood sample from ear; apathetic; lies on side	13.4	1.0646	
26	6:30 A.M.		Vomited during night			
	8:30 A.M.		Vomited; portion for analysis;			
	11:00 A.M.	120 hr.	blood sample from ear	14.0	1.0669	38.5
			Between 6 and 7 P.M. Died			

the loop, tissue necrosis, bacterial toxins, all contribute to the rapid demise of the animal, probably by effecting an earlier and sustained rise in blood potassium. This would involve the potassium-raising effect of dehydration, blood loss,¹⁹⁻²¹ and the release of potassium from injured tissue cells. Toxins of bacterial origin, such as histamine, may also contribute to this rise in potassium, since it has been shown that injections of histamine will raise blood potassium.²² The excess of potassium entering the blood stream might thus be satisfactorily accounted for as arising from the above-enumerated sources.

PROTOCOL S

Cat 3636. Male. Weight, 3.6 Kilos. Esophageal Obstruction at Cardiac End of Stomach by Tape

DATE	TIME	TIME AFTER OP.	CONDITION AND REMARKS	WEIGHT % LOSS	BLOOD DEN-SITY	BLOOD K MG.-%
Sept. 21	10:00 A.M.	0	Condition good		1.0503	30.0
	11:45 A.M.	0	Operation ended (15 min.)			
	12:30 P.M.	45 min.	Vomited frothy fluid		1.0563	20.8
	1:30 P.M.	1½ hr.	Vomited frothy fluid 4 times in last hour; constant licking	3.2	1.0563	
	2:15 P.M.	2½ hr.	Restless; retching; vomited twice	3.2	1.0563	
	5:45 P.M.	6 hr.	Vomited twice; resp. 106	5.5	1.0591	30.8
22	11:20 P.M.	11½ hr.	In past 5 hr. vomited twice; resp. varied from 34 to 83; refused milk and water; not so restless	7.1	1.0601	27.7
	12:10 A.M.		Vomited twice; still restless; drank 4 oz. water			
	1:10 A.M.		Heart rate 106; resp. 40; vomited twice			
	5:40 A.M.	18 hr.	Lying limp in cage	8.9	1.0622	
	10:30 A.M.	22½ hr.	Vomited twice; drank water	9.4	1.0641	27.5
	3:50 P.M.	28 hr.	Vomited twice; refused salmon; drank water and vomited	10.2	1.0678	
23	5:40 P.M.	30 hr.	Vomited once; restless; retching; drinks little; sits with head over bowl; urinated first time since operation	11.0	1.0660	32.2
	5:30 A.M.		Pulse 170; resp. 36			
	8:40 A.M.		Passed urine			
	12:15 P.M.	48½ hr.	Sits with head over bowl; body cold; hind leg weakness	14.9	1.0696	36.9
24	5:15 P.M.	53½ hr.	Drinks water	14.9	1.0669	38.5
	11:20 P.M.		Vomited			
	7:00 A.M.		Hind leg weakness			
	9:50 A.M.	70 hr.	Sits with head over bowl of water; drinks occasionally	16.6	1.0690	39.6
	11:30 A.M.		Vomited; lies stretched out; body cold; difficult to rouse; pulse 120; resp. 14	17.1	1.0713	45.3
	5:15 P.M.	77½ hr.				
	8:15 P.M.	80½ hr.	Died in coma; last blood sample from vena cava		1.0709	52.0

Autopsy: No peritonitis. Stomach, small intestine, and colon contracted. Bladder distended. Liver and spleen shrunken. Kidneys pale and soft. Adrenals pale. On opening the stomach the obstruction at the cardia was found complete. Esophagus dilated. No fluid in thoracic cavity. Lungs collapsed, pink; free from consolidation. Heart in diastole.

CASE REPORT
P. H., No. 448619. Fifty-Year-Old Jewish Tailor. Weight, 73 Kilos

DATE	INTAKE	OUTPUT	WATER BALANCE	BLOOD DENSITY	R.B.C.	Hg PER CENT	URINE SP. GR.	BLOOD CHEMISTRY	REMARKS
Sept. 24					5.04	93	1.035		Admitted with severe epigastric pain of 6 hours' duration. B. P. 115/ 85.
25	2000	2850	- 850		4.68	90	1.030	Potassium mg. % Plasma 29.8; Whole Blood 202; Cells 365. Hemato- crit: 47	EK: Cardiac muscle damage. X-ray of abdomen: "fluid levels."
26	2000	2775	- 1,025	1.05634	-	-	-		
27	2100	4350	- 2,875				1.040		Op.: Enterostomy. EK: Def. muscle damage.
28	5300	4300	- 2,965	1.0551				B.U.N.: 18 mg. %; Cl 504 mg.	X-ray: "Fluid levels and mottling both bases." Division of band. Oxygen tent.
29	3160	3930	- 3,735	1.0513	(After 200 c.c. 5% NaCl)			B.U.N.: 12 mg. %; CO ₂ 42 vol. %	EK: Changing conditions in muscle.
30	3595	5000	- 5,140	1.0524			1.025		
Oct. 1	5000	7950	- 8,090	1.0556				N.P.N.: 27 mg. %; ser. protein: 6.4%; CO ₂ 66 vol. %; Cl 542 mg. %.	
2	4145	5600	- 9,545	1.0543	5.72	90		Serum potassium: 17.2 mg. %; Na 135.2 m. eq./L; Ca 4.3 m. eq./L.	Profuse drainage fr. enterostomy.

CASE REPORT—CONT'D

3	4490	5350	-10,405	1.0554			Clyses were stopped, as patient's urine was over 1,000 c.c. per day. Taking fluids per mouth.
4	1100	3650	-12,955				Removed from oxygen tent.
5	1200	3400	-15,155	1.0552			Went into collapse. Cyanotic, cold, and clammy. B.P. 98/68. Transfusion. Oxygen tent. Blood density taken 6 hours after collapse; second determination after 2,000 c.c. of saline by elysis.
6	2325	3100	-15,930				
7	3500	2700	-15,130				X-ray: pneumonitis subsiding.
8	3175	3100	-15,055		1.022		Removed from oxygen tent.
9*	5600	2500	-11,955	1.0575		B.U.N.: 8 mg. %	Soft diet; 1 gm. NaCl t.i.d.
10	3250	2050	-10,755	1.0555			Tongue still dry.
11	4250	2900	-9,405	1.0567			Feels weak; no appetite.
12	3600	2800	-8,605				Feels better
13	3875	3400	-8,130				
14	3450	1500	-6,180				
15	3400	3100	-5,880				
16	3400	3300	-5,780	1.0556		Blood chlorides 500 mg. % Potassium mg. % Phasma 17.6; Whole Blood 198; Cells 367; Hematocrit: 49	
17†	1900	3150	-7,030				
18				5.22	86		Up in chair today.

Insensible loss from 9/25-10/8 figured at 2,000 c.c. per day; from 10/9-10/17 1,500 c.c. per day.

*Water content of soft diet estimated at 500 c.c. per day. (Coller and Maddock.^{4, 5})

†Fluid loss 10 per cent of body weight. Actual weight loss 14 per cent of body weight.

‡Specific gravity of blood.⁶

It may be supposed that in the human subject the amount of potassium liberated from blood extravasated into a strangulated loop would be much higher than in cats or dogs. The potassium content of the erythrocytes in these animals differs little from that of their plasma, whereas the human red blood cells contain 400 mg. per 100 ml., or 20 times as much as the plasma.

The normal means of elimination of potassium is by renal excretion. Zwemer and Truszkowski^{2, 4} first suggested that this function cannot be adequately carried out without the presence of the adrenal cortical hormone, and examination of the histologic appearance of the adrenal cortex in both clinical and experimental intestinal obstruction, indicated depletion of its hormone reserves according to Zwemer's²³ classification. Harrop et al.²⁴ have found that potassium retention is a prominent feature of corticoadrenal insufficiency. It is now suggested that high intestinal obstruction may, as far as potassium metabolism is concerned, be identified with adrenal insufficiency.

Although a major part in the regulation of the blood electrolyte levels is usually ascribed to the kidneys, there is evidence, in cases of renal insufficiency, that other means may be utilized to rid the body of injurious catabolites. Bliss,²⁵ Austin and Gammon,²⁶ and Ingraham and Visseher²⁷ have shown that in both dog and man, concentration of potassium in the gastric juice is higher than in blood. The last named authors, making simultaneous determinations in 24 dogs, showed the concentration of potassium in gastric juice to be, on the average, 2.7 times, and in extreme cases, 4 times greater than in plasma. In the case of Cat 3639, we found the vomitus to contain 254 mg. per cent of potassium when the blood level was 38.5 mg. per cent. Possibly, therefore, secretion of potassium into the gastric lumen followed by vomiting may be regarded as a part of an auxiliary or emergency mechanism for lowering blood potassium. An esophageal obstruction would therefore prevent this detoxifying function with consequent earlier death of the animal.

In this light, the removal of stomach contents by gastric or duodenal tube, together with the administration of saline, as advocated by Wangenstein²¹ in intestinal obstruction, is wholly justified. McIver,^{*} commenting on the use of duodenal drainage advocated in the treatment of distention, feels this to be one of the major advances of the past decade.²⁸⁻³⁰

The benefit of salt in the treatment of intestinal obstruction and of adrenal insufficiency may be explained by its action in lowering the concentration of potassium by blood dilution and favoring its excretion. Furthermore, Amberg and Helmholtz²² protected guinea pigs by means of sodium chloride against experimental potassium poisoning, and Bunge³³ has demonstrated that sodium protects against large

*McIver, M. A.: *Acute Intestinal Obstruction*, New York, 1934, Paul B. Hoeber, Inc.

amounts of potassium in the normal diet. Of importance is Thaler's²² contribution that intravenous saline solution lowered posthemorrhagic hyperpotassemia in cats. In rats with intestinal obstruction, Schnohr³⁴ found the survival period to be lengthened by administration of 10 per cent sodium chloride, and suggested that this salt facilitated the excretion of some "noxious product."

Recently, Heuer and Andrus have given cortical extract simultaneously with transfusion, thereby prolonging the lives of dogs receiving intravenous injections of aqueous extracts of closed intestinal loops.³⁵ Since corticoadrenal extract³⁶ lowers plasma potassium in both adrenalectomized and normal cats, and will protect normal mice and guinea pigs from fatal amounts of potassium,^{2, 4, 37} the therapeutic value of this measure would appear to be due to its effect on blood potassium.

Aird³⁸ stated that the chloride, sodium, and potassium content of the blood is low in intestinal obstruction. In a case of low ileal obstruction (P. H., No. 448619), we found a value of 29.8 mg. per cent potassium before operation and two values of 17.2 and 17.6 mg. per cent after operative and saline therapy.

In conclusion, we wish to emphasize that a high blood potassium is not peculiar to intestinal obstruction, but may be expected in all conditions associated with rapid or continuous excessive entry of potassium into the blood stream.^{39, 40}

We wish to thank Dr. Fuge for his help in Group A of these experiments and Dr. David Polowe, of Paterson, N. J., for the donation of the apparatus for blood density determination.

SUMMARY

1. In 8 cats it has been found that acute intestinal obstruction (esophagus, duodenum, jejunum, and colon) is associated with a rise in blood potassium to levels which have previously been shown to be lethal. The potassium content of obstructed loops, peritoneal fluid, and vomitus was many times that of blood.

2. The potassium rise is ascribed to some combination of dehydration, tissue breakdown, and action of bacterial toxin, with consequent adrenal and renal dysfunction resulting in adequate potassium elimination. The blood density parallels the rise in most instances.

3. It is suggested that potassium is the dialyzable toxic factor sought for in acute intestinal obstruction.

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THE URINARY LOSS OF IODINE FOLLOWING TOTAL THYROIDECTOMY

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TOTAL ablation of the thyroid gland as a therapeutic measure in the management of congestive heart failure or for the relief of angina pectoris has recently received wide attention. It was described in June, 1933, by Blumgart and his associates.¹ Reports of the principles involved and of the results obtained have subsequently appeared in the literature.²⁻⁶ The rationale for the total thyroidectomy is based upon extensive investigation which reveals a direct relationship between the velocity flow of the blood and the basal metabolic rate. The experimental background from which the procedure developed has been fully presented by Blumgart.⁷

The therapeutic significance of total thyroidectomy has been amply discussed in other and more extensive reports.⁸ We have performed the operation on 11 patients presenting various stages of cardiovascular disease. Save perhaps in one instance, so far as we were able to determine, the cardiovascular disease was not of thyrogenic origin. Our clinical results resemble in miniature those extensively described in larger series.⁹ Along with our clinical studies, however, we have taken this unusual opportunity to investigate the iodine metabolism of these patients.¹⁰ This investigation represents a continuation of studies concerning the relationship between the blood and urinary iodine and thyroid function.

Immediately following partial thyroidectomy for various forms of goiter there ensues a striking increase in the urinary excretion of iodine.¹¹ This eventually returns to normal. The significance of the blood iodine and of the daily loss of iodine in the urine has been demonstrated.^{12, 13} The fact that iodine metabolism is closely related to thyroid function is securely established. As a consequence, it seemed desirable to determine the urinary loss of iodine preceding, immediately following, and subsequent to, total thyroidectomy in man. The purpose of this paper is to report the results of this investigation.

LITERATURE

Alexander Sturm¹⁴ found a slight but definite increase in the urinary loss of iodine subsequent to total thyroidectomy in dogs. Curtis and Barron¹⁰ noted a definite increase in the urinary excretion of iodine

immediately following total thyroidectomy in man. This was associated with an immediate postoperative increase in the blood iodine, which then gradually decreased to about one-third the normal level.

The average normal daily loss of iodine in the urine, as determined on 12 of our University Hospital patients, ranges from 0.036 to 0.078 mg.,¹⁵ and averages 0.051 mg. The urinary excretion of iodine of patients with toxic goiter is increased during the untreated preoperative period.¹¹⁻¹³ Immediately following partial thyroidectomy there ensues an even greater loss, which may reach 2.0 mg. during the first twenty-four hours postoperatively.¹¹ Investigation of the urinary excretion of iodine following other than thyroid surgery also reveals an immediate increase in the postoperative loss.¹⁶ From these observations it appeared that at least part of this increased iodine loss was due to extrathyroid depletion.¹¹

METHODS

The urinary excretion of iodine was determined on 6 patients upon whom total thyroidectomy was accomplished for various stages of cardiovascular disease. In the first 2, small fragments of thyroid tissue in the adherent zone at the tracheoesophageal sulcus were not removed in order better to protect the parathyroids and the recurrent laryngeal nerves. The total remnant of thyroid tissue in each of these 2 patients was estimated to be less than one gram. In the remaining 4, total thyroidectomy in its strict literal sense was accomplished with due consideration to the blood supply of the parathyroid glands,¹⁷ and to the recurrent laryngeal nerves.

All patients were maintained in the Research Surgical Service of the University Hospital on a diet which omitted those foods known to be high in iodine. The observations of Cole, Curtis and Bone¹⁸ present the iodine content of our usual hospital diet. The patients were maintained either at bed rest or on limited physical activity. *Iodine was not used or administered in any form throughout their hospitalization.*

The collection of the twenty-four-hour urine specimens was carefully supervised. Blood samples for blood iodine determinations were drawn in the morning, in the postabsorptive state. Determinations of the blood and urinary iodine were made after the method of Phillips and Curtis.¹⁹ This is an adaptation of the von Fellenberg procedure.²⁰ A few urinary iodine determinations were made after Matthews' modification of the Leipert method.²¹ All determinations were made in duplicate.

Brief histories of the patients studied are presented. They include the principal findings and the management of each patient. These are accompanied by tables and figures which present the urinary excretion of iodine.

CASE 1.—*Hypertension With Congestive Heart Failure* (Fig. 1). A. W., a housewife, aged fifty-five years, entered the University Hospital on Oct. 12, 1933, for the management of hypertension with congestive heart failure. Dyspnea, weakness, palpitation, and precordial pain had been experienced intermittently for about two years. Respiratory distress was apparent on physical examination. A small hard nodule was palpated in the lower right lobe of the thyroid, which seemed otherwise normal. The physical findings were those of severe cardiac damage and congestive heart failure. Electrocardiographic studies revealed left ventricular preponderance. The blood pressure varied between 160/70 and 180/94. The trachea and larynx were normal.

Laboratory investigation revealed negative Wassermann and Kahn tests. A mild anemia was present. The white blood cells and differential counts were normal.

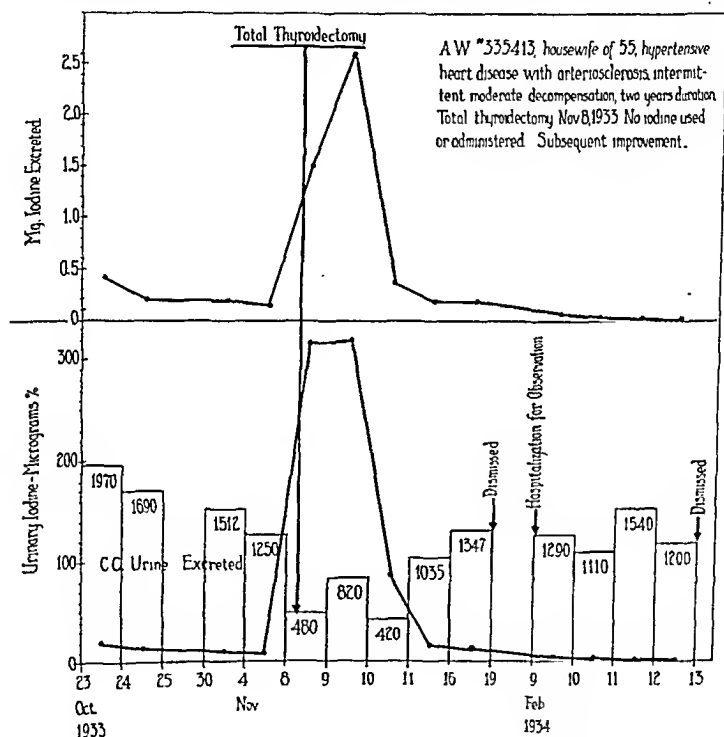


Fig. 1.—The urinary excretion of iodine following total thyroidectomy.

A trace of albumin and an occasional granular cast were observed on repeated urine examinations. Kidney function tests were within normal range. The blood N. P. N. was normal. The basal metabolic rate was plus 27, with the temperature 97.4°, the pulse 77, the respirations 23, the blood pressure 166/92, and the weight 118 pounds in the basal state.

During the preoperative period the daily urinary excretion of iodine ranged from 66 to 408 (0.066 to 0.408 mg.), and averaged 210 micrograms (0.210 mg.). The initial blood iodine was definitely increased to 55 micrograms per cent. It decreased during the preoperative period of preparation so that on the morning of operation it was 13.5 micrograms per cent. No iodine was used or administered.

Total thyroidectomy was accomplished on Nov. 8, 1933, using a basal anesthetic of avertin (50 mg. per kilogram) supplemented by local (novocaine 1/2 per cent) and

some gas (nitrous oxide) anesthesia. During the subsequent forty-eight hours there ensued a great increase in the urinary loss of iodine, Fig. 1. This rose to 2.6 mg. Subsequently, it gradually decreased, but was elevated at the time of dismissal from the hospital. The average daily urinary iodine excretion during the first eight postoperative days was 711 micrograms (0.711 mg.). For the entire postoperative period of eleven days, it averaged 553 micrograms (0.553 mg.).

The entire thyroid gland as removed weighed 40 grams. Within the lower right lobe there was one small colloid nodule. The remainder appeared to be normal. The microscopic appearance was normal. The iodine content of the whole gland was 24 mg. per cent, or 9.6 mg.

On Nov. 17, 1933, nine days after total thyroidectomy, the basal metabolic rate was plus 13, with the temperature 98.6°, the pulse 65, the respirations 21, the blood pressure 178/100, and the weight 123 pounds in the basal state. The blood iodine was 14.6 micrograms per cent. There were no complications. Convalescence was attended by considerable and definite symptomatic improvement. The patient was dismissed from the hospital on Nov. 19, 1933.

She was readmitted on Feb. 8, 1934, for investigation of the late results of total thyroidectomy. At this time observations on the blood and urinary iodine, the basal metabolic rate, and the clinical progress were made during a five-day period. There was definite clinical improvement. The daily urinary iodine loss ranged from 13 to 72 micrograms and averaged 39. The basal metabolic rate was minus 5, with the temperature 97°, the pulse 73, the respirations 19, the weight 131 pounds, and the blood pressure 198/120 in the basal state. The blood iodine averaged 1.6 micrograms per cent. The blood pressure fluctuated around 180/100.

Comment.—The average daily loss of iodine in the urine during the preoperative period was increased. Immediately following total thyroidectomy there ensued a greater increase. This persisted for about forty-eight hours and then gradually decreased. At the time of dismissal, however, it was still increased. Three months subsequent to total thyroidectomy, the urinary excretion of iodine was at a low normal range. At that time the blood iodine was the lowest we have thus far determined in man.

CASE 2.—Hypertension of Unknown Etiology (Fig. 2). E. K., a white housewife, aged thirty-eight years, entered the University Hospital on Oct. 26, 1933, for the management of "essential hypertension." Severe headaches with disturbance of vision had been present during the past twelve years. Frequent medical examinations revealed a persistent severe hypertension, averaging 230/130. There had been no clinical evidence of cardiac failure. Evidence of cardiac decompensation could not be obtained either by physical examination or by electrocardiographic studies. The trachea and larynx were normal. Ophthalmologic examination revealed old retinal hemorrhages.

Laboratory investigation revealed negative Wassermann and Kahn reactions. A mild anemia was present. The white blood cells and differential counts were normal. The serum calcium, phosphorus, and the nonprotein nitrogen of the blood were also normal. The kidney function tests were within normal range. The basal metabolic rate was plus 5, with the temperature 98.6°, the pulse 76, the respirations 14, the blood pressure 204/128, and the weight 124 in the basal state. *No iodine was used or administered.* The initial blood iodine was elevated, being 41 micrograms per cent. With dietary regulation and hospital bed rest it decreased to normal, Fig. 2. The preoperative average was 17.5 micrograms per cent. The urinary iodine ranged from 28 to 176 micrograms, averaging 77 micrograms daily.

Total thyroidectomy was accomplished on Nov. 21, 1933, using avertin (80 mg. per kilogram) supplemented by local anesthesia ($\frac{1}{2}$ per cent novocaine). There were no immediate or remote complications. The gland removed weighed 20 grams. Except for a small nodule at the posterior right pole, it was normal. The thyroid gland contained 98 mg. per cent iodine (dry basis) which is subnormal.

During the twenty-four hours subsequent to total thyroidectomy, there ensued a great increase in the urinary excretion of iodine. This increased to 2.5 mg. and then gradually subsided. The average daily postoperative loss of iodine for the first eight days was 547 micrograms. For the entire postoperative period it was 184 micrograms. The basal metabolism subsequently fell to minus 12, with the tempera-

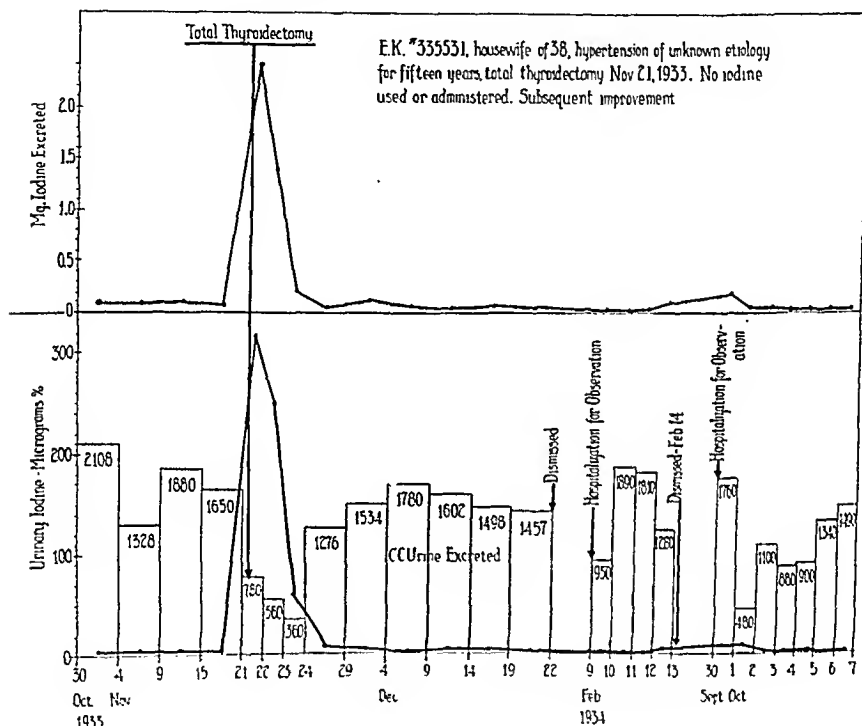


Fig. 2.—The urinary excretion of iodine following total thyroidectomy.

ture 97.8°, the pulse 65, the respirations 12, the weight 126 pounds, and the blood pressure 230/130. She was dismissed on Dec. 22, 1933, symptomatically improved.

She was readmitted on Feb. 8, 1934, for further investigation. There was definite evidence of myxedema. The blood pressure had returned approximately to its original level; however, symptomatic improvement still persisted. The basal metabolic rate was minus 25, with the temperature 98°, the pulse 63, the respirations 12, the blood pressure 190/130, and the weight 131 pounds in the basal state. The blood iodine averaged 6.0 micrograms per cent. The daily urinary iodine ranged from 22 to 72 micrograms and averaged 34. She was dismissed on Feb. 17, 1934.

She entered the hospital again on Sept. 29, 1934, for investigation of the late results of total thyroidectomy. During an eight-day period the daily urinary iodine

loss ranged from 20 to 174, averaging 51 micrograms. Myxedema was present. The basal metabolic rate was minus 21, with the temperature 98°, the pulse 68, the respirations 12, the weight 127 pounds, and the blood pressure 210/136 in the basal state.

Comment.—The preoperative urinary loss of iodine did not reveal the great variability observed in the preceding patient. Although some determinations were definitely elevated, the average daily excretion was at the upper limit of normal. During the twenty-four hours subsequent to thyroidectomy, there ensued a marked increase in the concentration of iodine in the urine. This gradually subsided, but was definitely increased at the time of the first dismissal from the hospital. Frequent subsequent determinations of the urinary iodine revealed low normal values.

CASE 3.—*Hypertension of Unknown Etiology* (Table I). H. G., a railroad fireman, aged forty-one years, entered the University Hospital on Apr. 3, 1934, for the management of "malignant hypertension." Nervousness, tinnitus, vertigo, and dyspnea had been present for about a year. Physical examination at the dispensary in September, 1933, revealed a severe hypertension. After admission to the hospital the blood pressure fluctuated around 210/140. The heart was moderately enlarged. No evidence of congestive heart failure was detected.

TABLE I

HYPERTENSION OF UNKNOWN ETIOLOGY OF ONE YEAR'S DURATION (CASE 3)

DATE	24-HOUR URINE VOLUME (C.C.)	IODINE MICRO- GRAMS %	IODINE EXCRETED IN MG.	BLOOD IODINE MICRO- GRAMS %	B. M. R. AND REMARKS
4/ 4/35	----	----	----	19.0	Plus 15
4/ 9/35	----	----	----		Plus 0
4/11/35	730	15.4	0.112		
4/12/35	1160	4.3	0.050	33.0	
4/13/35	1240	4.4	0.055		
4/14/35	----	----	----		
4/15/35	900	14.4	0.130		
4/16/35	1800	5.5	0.099	30.0	
4/17/35	2380	3.0	0.086		
4/18/35	1990	3.0	0.060	12.7	Minus 12
4/19/35	----	----	----	20.0	Preoperative
TOTAL THYROIDECTOMY, APRIL 19, A.M.					
4/19/35	440	370.0	1.630	54.0	1 hr. postoperative
				29.0	3 hr. postoperative
				57.0	6 hr. postoperative
4/20/35	470	860.0	2.010	29.0	24 hr. postoperative
				13.1	30 hr. postoperative
4/21/35	880	121.0	1.070		
4/22/35	1760	23.0	0.400		
4/23/35	1650	6.8	0.112	11.3	
4/24/35	1490	2.4	0.036		
4/25/35	880	11.3	0.099	6.3	
4/26/35	870	5.5	0.048		Minus 10
4/27/35	1640	2.6	0.043	4.6	
4/28/35	1680	3.3	0.056		
4/29/35	1440	4.2	0.060	4.1	
Dismissed April 30, 1934					

Laboratory investigation revealed negative Wassermann and Kahn reactions. The urine on repeated examinations was normal. There was no disturbance in kidney function. The nonprotein nitrogen of the blood was 32 mg. per cent. No abnormality was noted in other chemical analyses of the blood. The trachea and larynx were normal. The basal metabolic rate was plus 15, with the temperature 98.6°, the pulse 66, the respirations 11, the weight 179 pounds, and the blood pressure 184/92, in the basal state. *No iodine was used or administered.*

The blood iodine was increased but with adequate bed rest and dietary regulation this soon fell to normal, 12.7 micrograms per cent. The urinary iodine varied from 10 to 130, averaging 75 micrograms daily.

Total thyroidectomy was performed on Apr. 19, 1934, using avertin (80 mg. per kilogram) supplemented by local and gas anesthesia. There were no immediate or remote complications. The thyroid gland weighed 15 grams. Two small calcified nodules were found upon section. Otherwise the gland was normal. The whole gland contained 25 mg. per cent, or 3.8 mg. of iodine.

During the first twenty-four hours subsequent to total thyroidectomy, the urinary iodine increased to 1.6 mg. It subsequently gradually decreased and reached a normal range before the patient's dismissal from the hospital. The average daily urinary excretion of iodine for the first eight days postoperative was 672 micrograms. For the entire postoperative period of eleven days it averaged 464 micrograms. Associated with the immediate postoperative increase in the urinary iodine, there occurred a simultaneous increase in the blood iodine to 57 micrograms per cent (Table I). It then gradually decreased and eventually fell as low as 4.1 micrograms per cent (Table I).

Comment.—Although the preoperative urinary loss of iodine varied considerably, the average daily loss was at the upper range of normal. A great increase followed total thyroidectomy. This gradually subsided, so that at the time of dismissal the urinary excretion of iodine was normal. The blood iodine rapidly decreased to about one-third normal.

CASE 4.—Hypertensive Heart Disease With Congestive Heart Failure (Table II). F. S., a white male, aged fifty-four years, entered the University Hospital on Apr. 3, 1934, for the management of hypertensive heart disease with recurrent severe decompensation. Hypertension had been present for many years. The severity of the congestive heart failure had increased in spite of medical management elsewhere. The physical findings were those of congestive heart failure. The blood pressure ranged between 180/98 and 202/108. The basal metabolic rate was minus 16, with the temperature 99°, the pulse 70, the respirations 16, and the weight 146 pounds in the basal state. *No iodine in any form was used or administered.*

Laboratory investigation revealed negative Wassermann and Kahn reactions. The blood picture was normal. Upon repeated urine examinations, only a trace of albumin was detected. The blood iodine was normal, Table II. During the preoperative period the daily urinary iodine ranged from 22 to 110, averaging 54 micrograms.

Total thyroidectomy was accomplished on May 2, 1934, using avertin (80 mg. per kilogram) supplemented by local anesthesia. The thyroid gland weighed 18 grams. There was an occasional small colloid nodule; otherwise the gland was normal. Analysis revealed an iodine content of 97 mg. per cent (dry basis), which is subnormal. For ninety-six hours after thyroidectomy there was a great increase in urinary excretion of iodine. This rose to 2.2 mg. and then gradually decreased.

TABLE II

HYPERTENSION WITH RECURRENT CONGESTIVE HEART FAILURE FOR MANY YEARS
(CASE 4)

DATE	24-HOUR URINE VOLUME (C.C.)	IODINE MICRO- GRAMS %	IODINE EXCRETED IN MG.	BLOOD IODINE MICROGRAMS %	B. M. R.
4/ 9/35	----	----	----		Minus 16
4/21/35	1980	1.1	0.022	10.2	
4/22/35	2420	2.0	0.048		
4/23/35	3220	----	----	8.5	
4/24/35	2970	3.7	0.110		
4/25/35	2440	2.1	0.051	10.1	
4/26/35	2700	1.8	0.049		
4/27/35	2000	2.7	0.054	11.2	
4/28/35	1240	2.6	0.032		
4/29/35	1830	3.8	0.069	10.1	
4/30/35	2000	2.6	0.052		Minus 16
5/ 1/35	1980	2.6	0.052		
5/ 2/35	----	----	----	7.6	
				(preoperative)	
		TOTAL THYROIDECTOMY, MAY 2, A.M.			
5/ 2/35	680	175.0	1.190	23.0	
				(2 hr. postoperative)	
				26.0	
				(4 hr. postoperative)	
				28.0	
				(6 hr. postoperative)	
				37.0	
				(9 hr. postoperative)	
5/ 3/35	420	270.0	1.150	28.0	
				(24 hr. postoperative)	
5/ 4/35	1320	170.0	2.240		
5/ 5/35	1190	170.0	2.023		
5/ 6/35	1190	----	----		
5/ 7/35	----	----	----	15.0	
5/ 8/35	640	41.0	0.260		
5/ 9/35	240	23.0	0.055		
5/10/35	300	24.0	0.072		
5/11/35*	440	13.0	0.057		
5/21/35	----	----	----		Minus 20
5/22/35	----	----	----	12.6	
6/ 8/35	----	----	----	6.9	

*The determinations of urinary iodine terminated on this day.

The average daily excretion of iodine during the postoperative eight days was 881 micrograms. Simultaneous with this increased urinary loss the blood iodine increased to 37 micrograms per cent, Table II, and then gradually decreased. It fell to 6.9 prior to dismissal from the hospital. The basal metabolic rate at this time was minus 20, with the temperature 97.8°, the pulse 44, the respirations 20, the weight 160 pounds, and the blood pressure 210/120 in the basal state. Throughout the postoperative course, the blood pressure fluctuated around 204/100. No immediate or remote complications were encountered.

Comment.—The preoperative average daily urinary excretion of iodine was within normal range. Immediately following total thy-

roidectomy the characteristic increase in the urinary loss of iodine ensued. This gradually subsided so that at the time of dismissal it had returned to normal.

CASE 5.—*Chronic Myelogenous Leucemia With Congestive Heart Failure* (Table III). A. D., a white male laborer, aged fifty-four years, entered the University

TABLE III

RECURRENT CONGESTIVE HEART FAILURE OF 8 MONTHS' DURATION (CASE 5)

DATE	24-HOUR URINE VOLUME (C.G.)	IODINE MICROGRAMS %	IODINE EXCRETED IN MG.	BLOOD IODINE MICROGRAMS %	B. M. R.
10/23/35	490	2.8	0.014		
10/24/35	1040	2.0	0.021		
10/25/35	1520	2.8	0.043		
10/26/35	1550	10.6	0.164		
10/27/35	1420	2.5	0.036		
10/28/35	1260	2.2	0.028	13.6	
10/29/35	1310	1.9	0.025		
10/30/35	1540	2.1	0.032		
10/31/35	1380	2.3	0.032		
11/ 1/35	1710	2.8	0.048		
11/ 2/35	1400	9.8	0.137		
11/ 3/35	730	2.3	0.017		
11/ 4/35	1160	2.6	0.030		
11/ 5/35	1480	2.5	0.037		
11/ 6/35	1360	4.4	0.060		
11/ 7/35	1280	3.7	0.050	7.9	Plus 41
11/ 8/35	1640	16.0	0.260	10.1	Plus 55
11/ 9/35	610	5.3	0.032	11.6	
11/10/35	1320	4.1	0.054		Plus 58
11/11/35	660	7.2	0.048		
11/12/35				7.4	
				(preoperative)	
TOTAL THYROIDECTOMY, NOVEMBER 12, A.M.					
11/12/34	600	215.0	1.292	16.8	
				(4 hr. postoperative)	
				21.0	
				(7 hr. postoperative)	
11/13/35	920	104.0	0.960	15.0	
11/14/35	1120	53.0	0.590	(24 hr. postoperative)	
11/15/35	1130	20.0	0.230	9.3	
11/16/35	1250	7.1	0.089		
11/17/35	1060	5.6	0.059		Plus 34
11/18/35	980	5.4	0.053		
11/19/35	---	---	---	7.4	
11/20/35	770	5.2	0.040		
11/21/35	680	4.4	0.030		
11/22/35	1190	5.7	0.068		
11/23/35	1140	4.9	0.056		
11/24/35	1240	3.9	0.048		
11/25/35	1450	5.5	0.080		
11/26/35	---	---	---		Plus 18
11/27/35	800	4.5	0.036	6.3	
11/28/35	1780	5.2	0.093		Plus 20
11/29/35	1150	8.4	0.097		
11/30/35	---	---	---		Plus 16

Daily observations were continued until June 1, 1935. The urinary iodine remained within the normal range. The B. M. R. eventually fell to minus 13.

Hospital for the management of myelogenous leucemia with associated arteriosclerotic heart disease. About a year prior to admission he noticed a rapidly enlarging spleen. This was treated by intense x-ray therapy which resulted in a moderate reduction in its size. He was discharged from the hospital on Feb. 17, 1934. Shortly after his dismissal from the hospital he became aware of increasing dyspnea and edema of the feet and ankles, which became progressively worse.

He was readmitted to the University Hospital on Oct. 13, 1934, for further investigation. The physical findings were those of congestive heart failure. Laboratory examination was essentially negative save for the blood picture, which was that of chronic myelogenous leucemia. The basal metabolic rate fluctuated between plus 30 and plus 58 with the temperature 98.6°, the pulse 72, the respirations 17, the weight 145 pounds, and the blood pressure 106/56 in the basal state. *No iodine in any form was used or administered.*

The blood iodine ranged from 7.4 to 14.7 and averaged 10.6 micrograms per cent. The loss of iodine in the urine during the period of preoperative preparation ranged from 14 to 260 micrograms, and averaged 58 daily.

Total thyroidectomy was accomplished under a basal anesthesia of avertin with supplementary novocaine on Nov. 12, 1934. The gland removed was morphologically normal and weighed 10 grams. It was pale and soft. It contained 4.7 mg. of iodine. During the twenty-four hours subsequent to total thyroidectomy, the urinary iodine rose to 1.3 mg. The average daily urinary loss during the first eight days postoperative was 414 micrograms. This subsequently returned to normal. Associated with the immediate postoperative increase in the urinary iodine, there was a corresponding increase in the blood iodine, to 21 micrograms per cent. This subsequently fell as low as 4.5. Except for subcutaneous capillary hemorrhage during the first twenty-four hours after the total thyroidectomy, there were no complications.

Comment.—The effect of total thyroidectomy on the leucemic blood picture is to be reported elsewhere. The average daily preoperative excretion of iodine was normal. Following total thyroidectomy, the characteristic transitory increase in the urinary loss of iodine was noted. The urinary iodine gradually returned to a low normal range.

CASE 6.—*Chronic Myelogenous Leucemia With Congestive Heart Failure* (Fig. 3). S. R., a white male laborer, aged forty years, was admitted to the University Hospital on Jan. 18, 1935, for diagnosis. About fifteen years ago he noticed intermittent sharp pain in the left upper quadrant. Since that time he has experienced similar recurrent pain in this region. In June, 1923, a splenomegaly was discovered, for which splenectomy was performed elsewhere. Hodgkin's disease was suspected at that time. About a month after the splenectomy his white blood count was 50,000. There was an associated anemia. Bleeding from the gums occurred at intervals, and as a result his teeth had been extracted. About five weeks prior to his admission he became aware of dyspnea on exertion, swelling of the abdomen, and also edema of the feet and ankles. Physical examination revealed findings characteristic of congestive heart failure.

The hematologic picture was that of chronic myelogenous leucemia. The basal metabolic rate was plus 15 with the temperature 97.6°, the pulse 77, the respirations 15, the blood pressure 168/108, and the weight 169 pounds in the basal state. Because of the congestive heart failure, total thyroidectomy was advised and accomplished on Feb. 26, 1935, using a basal anesthesia of avertin supplemented by

novocaine locally. The gland removed weighed 24 grams. It revealed no evidence of abnormality. Except for moderate controllable subcutaneous oozing from the wound during the first twenty-four hours following the total thyroidectomy, there were no complications.

During the preoperative period the urinary iodine varied from 17 to 153, averaging 91 micrograms daily. During the twenty-four hours subsequent to total thyroidectomy it increased to 2.0 mg. The average daily urinary excretion for the first eight postoperative days was 385 micrograms. It gradually decreased, so that at the time of dismissal it was at the lower range of normal. The average daily postoperative loss of iodine in the urine during an eleven-day period was 262 micrograms.

At dismissal, March 17, 1935, the basal metabolic rate was minus 5, with the temperature 97.4°, the pulse 74, the respirations 15, the weight 150 pounds, and the blood pressure 140/90 in the basal state.

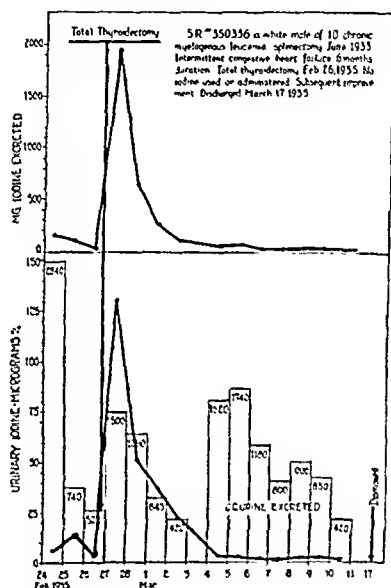


Fig. 3.—The urinary excretion of iodine following total thyroidectomy.

Comment.—During the preoperative period the average daily urinary excretion of iodine was increased over normal. Immediately following total thyroidectomy there was an even greater increase. This gradually decreased to the lower range of normal.

DISCUSSION

The duration of postoperative hospitalization of the six patients varied, depending upon the clinical improvement and the extent of subsequent investigation. The results of the first eight postoperative days are presented for comparison in Table IV. The average daily loss of iodine during the entire postoperative periods is noted in the individual case reports.

Table IV summarizes the average daily preoperative loss of iodine. Two of the patients fall within the normal range. Two are at the upper limit and two are definitely high. The preoperative grand average is 0.094 mg. This is higher than normal.¹⁵ The reason for the increased blood iodine,¹⁰ as well as the greater urinary loss, is not wholly clear. It may be a metabolic manifestation of cardiovascular disease. Perhaps secondary demands are made by the primary disease upon the thyroid mechanism as related to oxidation. Conceivably the nonthyroid iodine metabolism may be involved. Further investigation is necessary.

TABLE IV

LOSS OF IODINE IN THE URINE FOLLOWING TOTAL THYROIDECTOMY

PATIENT NO.	DIAGNOSIS	PREOPERATIVE DAILY IODINE EXCRETION		POSTOPERATIVE DAILY IODINE EXCRETION	
		RANGE	AVERAGE	RANGE	AVERAGE
		MG.	MG.	MG.	MG.
1	Hypertensive heart disease	0.066 to 0.408	0.210	2.635 to 0.043	0.711
2	Hypertension	0.028 to 0.176	0.077	2.470 to 0.031	0.547
3	Hypertension	0.010 to 0.130	0.075	1.630 to 0.036	0.672
4	Hypertensive heart disease	0.022 to 0.110	0.054	2.240 to 0.055	0.881
5	Chronic myelogenous leukemia with congestive heart failure	0.014 to 0.260	0.058	1.290 to 0.053	0.414
6	Chronic myelogenous leukemia with congestive heart failure	0.017 to 0.153	0.091	1.950 to 0.011	0.385
	Grand average preoperative		0.094	Grand average for first eight days post-operative	0.601

Considerable variability in the postoperative urinary excretion of iodine was observed. The average daily loss during the first eight postoperative days ranged from 2.635 mg. down to 0.011 mg. The grand average was 0.601 mg. It is obvious from these data that *immediately following total thyroidectomy for cardiovascular disease there ensues a great increase in the urinary loss of iodine.*

Cattell²² determined the urinary excretion of iodine during iodine medication in patients with exophthalmic goiter. He observed a post-operative *decrease* in iodine elimination. This was most evident during the first three postoperative days. The increased postoperative loss which we report is comparable to that observed following partial thyroidectomy by Curtis and Phillips.¹¹

Thyroidectomy in man, either partial, subtotal, or total, is thus followed by a transient but definite increase in the urinary loss of iodine. This persists for a varying period and then subsequently returns to normal. Up to 5 mg. of iodine may be thus rapidly lost. An adequate explanation for this is not at present possible. Manipu-

lation and trauma to the thyroid gland possibly account for a part of the immediate increase. These factors, however, do not account for its persistence. Too, we have observed¹⁶ that following non-thyroid operations on remote parts, such as astragalectomy, herniorrhaphy, and thoracoplasty, there is also an immediate postoperative increase in the urinary loss of iodine which persists for a varying period. It is possible that such procedures stimulate the thyroid gland to liberate increased amounts of iodine-containing substances, hence the postoperative increase in the blood iodine as well as the increased urinary loss. Both, however, occur following total thyroidectomy. After due consideration of the data available, a more comprehensive hypothesis is that the increased loss of iodine in the urine is a result of depletion of the extrathyroid tissues.

CONCLUSION

Following total thyroidectomy for cardiovascular disease, there ensues a great increase in the urinary loss of iodine. This is variably transient, usually persisting for about forty-eight hours. The daily iodine excretion subsequently returns to a lowered normal range. These data present added evidence that a part of this increased postoperative loss of iodine originates from the extrathyroid tissues. It is possible that the thyroid gland exerts an as yet unrecognized effect upon the tissue iodine.

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VENOUS STASIS ACCELERATES BONE REPAIR

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IN 1930 we¹ reported clinical and experimental observations leading to the conclusion that bone repair was accelerated by venous stasis. At that time it was pointed out that stasis hyperemia had been used clinically since the time of Ambroise Paré to promote the formation of callus in fractures. The statement of Nicoladoni that "an artificially produced and permanently maintained hyperemia will exercise a powerful stimulus on the tissues and tissue elements which participate in callus formation" was quoted. Others advocating venous stasis to increase deficient callus formation and to stimulate bone regeneration were mentioned. Our own experience in clinical cases was given.

References were also cited to show that many observers had noted the correlation between venous stasis and the overgrowth of bone in pathologic states. Conditions such as meningioma, long-standing leg ulcers, arteriovenous aneurysms, hemangiectasis, varicose veins, and congestive cardiac failure, have been considered responsible for increases in the length and thickness of bone. Harbin² has observed this effect in a patient with nevus and congenitally enlarged veins, and recently Harris and McDonald³ have reported a similar change following extensive thrombophlebitis of the femoral and iliac veins.

Finally, twelve experiments in dogs were reported in which both fibulas were divided and the popliteal vein of one side was ligated. In eleven of these twelve experiments the accelerated healing due to venous stasis was manifested by earlier formation of callus and earlier union.

From these data we concluded that venous stasis caused stimulation of bone growth. We reemphasized this in a subsequent paper.⁴

Observations were made later by McMaster and Roome⁵ who repeated our experiments and confirmed our results. They sectioned the dog's fibula, compared healing with and without vein ligation, and concluded that "experimental venous stasis in dogs hastened bone repair." In a second paper Roome and McMaster⁶ demonstrated that heterotopic bone is also increased by venous stasis. They made autotransplants of the mucosa of the urinary bladder into the muscles of the dog's hind legs. On one side the veins were occluded, and here a greater amount of bone was formed in the transplant. By this ingenious experiment the authors contributed evidence different from any previously offered on the subject.

From the foregoing statements one might consider as a fact that bone growth was stimulated by venous stasis. It was so considered until Key and Walton⁷ threw doubt upon it by failing to produce the effect in dogs. They admit that they have obtained healing in clinical cases of delayed union of fractures treated by passive hyperemia, so that apparently only the experimental findings are questioned.

Key and Walton tried our experiment on the fibula in six dogs which, when killed for study in ten weeks, showed only one instance of firmer union on the ligated side. They judged this to be due to the "unhappy choice of the site of bone defect." This is rather an amazing statement, for the fibula has been used by Harvey and his coworkers,⁸ McMaster and Roome,⁹ Zollinger,⁹ Sweeney and Laurens,¹⁰ and others for experiments on bone repair. Moreover, we selected it only after careful dissections had shown that it had the best relation of venous return to bone defect for a test of our question. Key and Walton, however, felt that the ulna was a preferable location. They operated upon twenty-four dogs, resecting approximately 0.5 cm. of bone and tying all the veins in sight, so that the animals' legs become edematous for two weeks or more. No difference in healing was observed between the ligated and control sides and on the strength of this, the authors challenged our findings.

When we read their paper, we felt that they had condemned our results *without adequately repeating our experiments*. They discarded the fibula after six experiments, the results of which were judged, as far as one can tell, from sacrifice of the animal at the arbitrary time of ten weeks, without taking serial roentgenograms to observe the rate of healing. In their work on the ulna, conditions prevailed that were absent from our experiments, for they ligated "all the large veins which could be identified in the region of the elbow" (both superficial and deep), causing persistent swelling and edema. This indicates circulatory failure and must have been associated with impaired function of the extremity; therefore a comparison was made between conditions resulting in circulatory and functional disability and those in which these factors were absent. This did not look right, but as Key and Walton were attacking the validity of our results on the basis of these experiments, we felt obliged to repeat them.

RESECTION OF THE ULNA

We originally intended to do a series of ulnar resections, but after operating upon seven dogs we were convinced that it was a poor place for the experiment. For not only was there postoperative swelling, edema, and disability from the indiscriminate tying of veins, but also there was *excessive bleeding* at the time the bone was sectioned. The latter was sometimes venous, sometimes arterial, and came from deep within the wound. This demanded an explanation, for it violated the premise that the only alteration of the circulation was that produced

intentionally to create the conditions of the experiment. Consequently, the blood supply of the dog's foreleg was studied by dissection. It was found that the volar interosseous artery and vein (or veins) occupied most of the space between the radius and the ulna (Fig. 1). These vessels in the dog are as large as any others in the foreleg. With all the muscles stripped off the leg, and the bone and vessels in view, it was sometimes impossible to do a subperiosteal resection of the ulna without injuring them. In fact, occasionally one could not insert a knife blade between bone and artery without damage to the latter. Imagine the uncertainty of trying to avoid these vessels while working through a surgical incision!

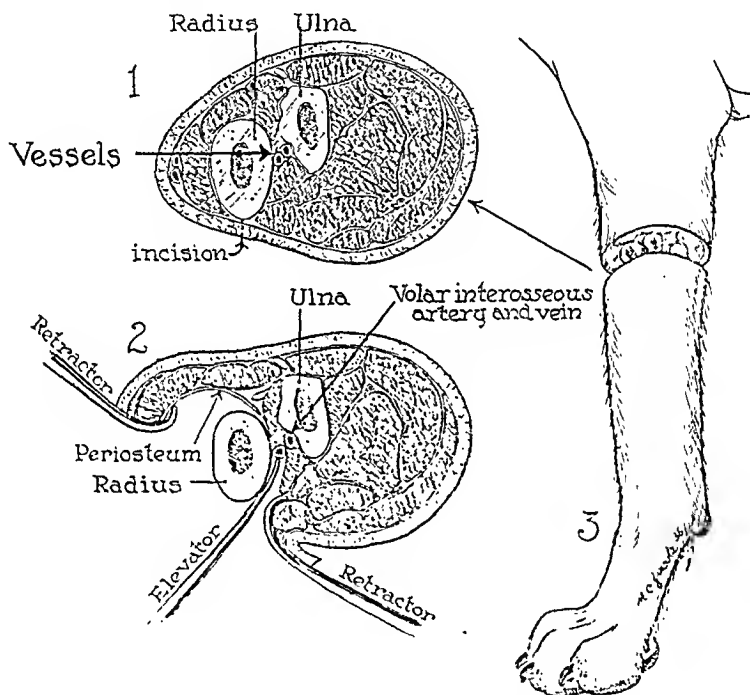


Fig. 1.—The anatomy of the dog's foreleg. 1, a cross-section illustrating the intimate relation of the volar interosseous vessels to the bone; 2, a schematic drawing to show how these vessels may be injured in the operation of Key and Walton.

We found, as did Key and Walton,² that there was no increase in the rate of bone repair on the side having the veins tied. But we considered the results meaningless in view of the uncontrolled factors existing in the experiment.

OTHER LOCATIONS FOR BONE RESECTION

As Key and Walton did not like our use of the fibula and we felt even more strongly about their selection of the ulna, it appeared desirable to try some other location for the experiment.

We tried removing a segment of the radius, but here, as with the ulna, damage to the interosseous vessels occurred; therefore the foreleg was eliminated as a suitable site for trial. The next attempt was to create bilateral burr holes in the skull, but here the arrangement of the diploic veins made it impossible to obtain unilateral venous stasis. Next, bilateral rib resections were tried and the intercostal veins were ligated and divided on one side. A preliminary series of four experiments was done in this manner. In all it was found that the small intercostal veins regenerated rapidly by collaterals, thus preventing adequate venous hyperemia. Then defects in the tibia were tried, first by creating a U-shaped defect in the crest, and later by burr holes just below the tubercle. It was found that the defects in the tibial crest smoothed out



Fig. 2.—When a burr hole in the tibia is used to study bone repair, a false impression of healing of the defect is given by slight rotation of the leg in taking the x-ray (right).

in healing so that no sharp end point could be relied upon; hence they were discarded. Since the burr holes through the tibia just below the tubercle appeared more satisfactory, nine dogs were operated upon, burr holes being made in both sides and the popliteal vein ligated in one leg. In view of the collateral anastomoses about the knee joint one might question the amount of venous stasis produced, but this was not the most serious objection, for it was found that unless the direction in which the burr hole, overlapping of the edges occurred, giving the impression of greater calcification than actually existed (Fig. 2). This made one distrust the results, and even though some of the animals showed accelerated bone repair on the side of the venous stasis, the findings were considered inconclusive.

To satisfy our requirements it was necessary to do the bone resection in such a way that postoperative splinting was eliminated, functional disability was minimized, and damage to the circulation avoided. In addition, the venous stasis had to be adequate in the region of the bone defect, yet cause a minimum change in the remainder of the circulation. We had originally chosen the fibula as best meeting these requirements, and after trying other locations, we were convinced that it was the most desirable location for the purpose.

RESECTION OF FIBULA

It was decided to repeat our original experiments; eighteen dogs were operated upon, resecting between 3 and 4 mm. of both fibulas in the upper third and ligating the popliteal vein on the right. This technic has been described,¹ but it might be well to amplify some details. The bone resection is easier if the hind legs are placed on round sandbags supporting the upper calf, and the ankle is pulled to the edge of the table by a strap. This steadies the legs and flattens out the muscles. Bleeding is avoided by approaching the fibula through intermuscular septa, but when the bone is reached, muscle is found to attach to the periosteum. The fibers, however, run laterally from each side so that, approaching from the back, it is usually possible to cut the periosteum for an inch without dividing any muscle. The placing of a small mastoid retractor at this stage gives good exposure, after which the periosteum may be freed. This requires care, for the periosteum is thin, but with delicate instruments and technic its separation is not particularly difficult. The best tools are a slightly curved, thin, blunt elevator about 5 mm. wide, which is often used in submucous resection, or a dental elevator, which is usually a little narrower. A right-angle dental elevator is sometimes useful to free the undersurface of the bone. After separating the periosteum, it is held down in order that the bone may be lifted and cut with a small Hibbs spinous process cutter.

Attention is given the details of bone resection, for it is our feeling that most failures can be traced to improper technic resulting in loss of continuity of the periosteum, thus allowing muscle to interpose between the fragments. Another possible error is to mistake the lesser saphenous vein for the smaller, more concealed popliteal at the time of vein ligation. If this is done, no venous stasis results in the region of bone resection.

The technic of our experiments on the fibula has become as nearly standardized as any surgical operation could be. Thus we may confidently expect that if a result is obtained, it will be due to the conditions of the experiment and not to chance. We found that of the 18 dogs having bilateral resection of the fibula and unilateral popliteal vein ligation, 14 showed accelerated healing on the side having the vein tied (Fig. 3). In 2 animals there was no difference in the rate of repair,

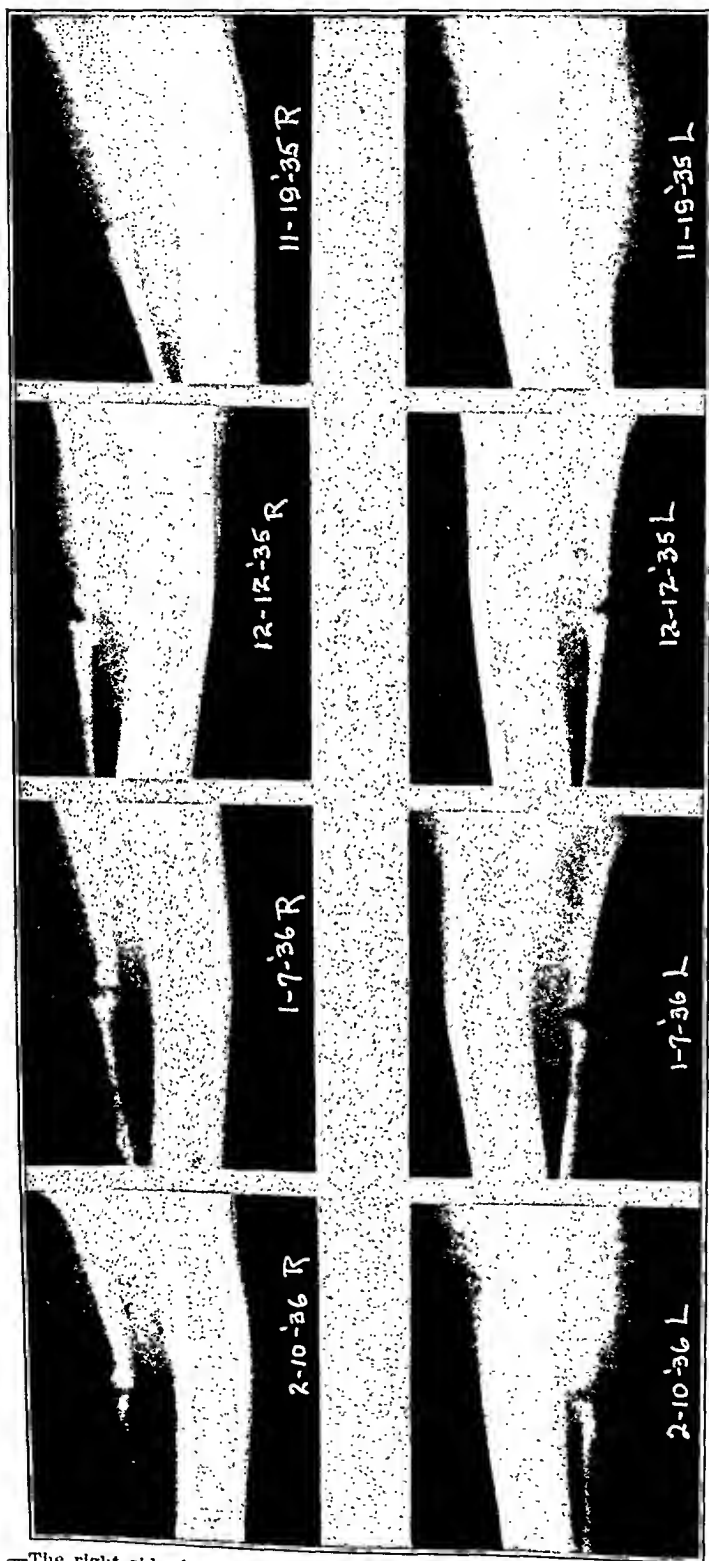


Fig. 3.—The right side (shown to the left in the illustration) reveals the accelerated healing with venous stasis in comparison to the normal repair on the left.

and 2 died of distemper before the experiment was completed. Combining these results with those already published, one finds that of 30 experiments, 25 showed increased bone growth with venous stasis, 3 had no change, and 2 were terminated by the death of the animals. Eliminating the latter from calculation gives 25 out of 28, or 90 per cent of the animals, which showed accelerated bone repair with venous hyperemia. The increase in rate of healing was considered moderate or extreme in 15 and only slight in the remaining 10. These latter were all in our recent series and rather surprised us, for we had observed no *slight effects* in our original experiments. The apparent explanation was found, however, in the fact that 8 of the 10 were young dogs. In young animals bone defects heal in about five weeks rather than the nine or ten weeks required by the mature adult. It was felt that the speed of this reparative reaction was such that it could not be increased much beyond the normal rate of repair; hence the effect of the venous stasis was not as apparent as in the older animals.

SUMMARY

In previous publications we showed that venous stasis had long been used to accelerate the healing of fractures, an observation which we were able to confirm. Moreover, many writers had noted the overgrowth of bone when venous hyperemia was caused by pathologic processes. In addition, 28 experiments on dogs' fibulas have revealed increased healing in 25 (90 per cent) of the animals, on the side having venous congestion produced by ligation of the popliteal vein. This observation has been confirmed by McMaster and Roomé⁵ who, in addition, showed that heterotopic transplants of bone grew more rapidly with venous hyperemia. Although this fact has been questioned by Key and Walton,⁷ we feel that the weight of evidence is sufficient to warrant reiteration of our contention that venous stasis stimulates bone growth.

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SYNOVIOMA

REPORT OF FIFTEEN CASES WITH REVIEW OF LITERATURE

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UNTIL a decade ago, little attention had been paid to a form of malignant tumor occurring in or about joints, characterized by a distinctive histologic appearance, a tendency to recur after excision and often to metastasize to the lungs. Their origin from synovial membrane is now established. They may be found, therefore, within the joint cavity, but may also arise from bursae, or from pouches or prolongations of the joint. They may also involve connective tissue, tendon sheaths, and lymphatics. They may give rise to symptoms which may simulate many of the more common conditions arising within the joints.

HISTORICAL

One of the first cases of primary synovial tumor was reported in 1865 by Langenbeck.¹⁰ In 1894, Hardie and Salter⁶ reported one case and mentioned another. C. B. Lockwood¹² and G. R. Turner¹⁶ each reported a case in 1902. In 1910, Lejars, and Rubens Duval¹¹ published a case report. Then Faceini, cited by Smith,¹⁵ reviewed all cases to 1923. Four years later Lawrence Smith¹⁵ added three cases, introducing the term "synovioma," which, while it departs from the custom of designating a tumor according to its embryologic origin, has several advantages. As Smith has pointed out, the term obviously indicates the tumor's origin, yet "offers a loophole of escape when the exact tissue of origin is debatable." It is one that easily lends itself to classification in any published index, and follows the precedent for nomenclature in such tumors as hypernephroma and meningioma.

Talbot, cited by Faulkner,⁵ added three cases in 1928, his discussion being limited to primary synovial membrane tumors containing giant cells. In 1931, Razemon and Bizard¹⁴ reviewed the literature for all primary tumors of the articulations and found 74 cases. Of these, 29 were malignant fibro spindle cell sarcoma. Many of these tumors were called "Tumeurs a cellules geantes," these being subdivided into the diffuse and circumscribed. Although one cannot be certain these might be classed as synoviomias. There are eight well-defined cases included in this report that are probably of synovial origin; of these, six were in the knee; five recurred after excision requiring a second

wide excision or amputation; three patients died of pulmonary metastases within one year after the first symptoms were noticed. L. C. Wagner¹⁷ also reported two cases in 1931. One of these, a synovioma of the right knee, recurred after local excision and finally came to amputation. Postoperative treatment included irradiation and a thorough course of Coley's toxins. The patient remained well for ten years and is one of the few known to have survived a five-year period. He died, however, of pulmonary metastases in October, 1935. The second patient is well three years following local excision at the ankle. Again the literature was briefly reviewed by Faulkner⁵ in 1931 and two cases were added. Both of these occurred in the knee, were excised locally, and were given high voltage x-ray therapy with no evidence of recurrence or metastasis six years later. In 1933, Leila Charlton Knox⁸ added three cases. Two of these patients died of pulmonary metastases four and six years, respectively, following amputation. In one of these cases the chest metastases were treated with high voltage x-rays, but with no improvement. In April, 1934, W. B. Coley³ presented before the New York Surgical Society a case of synovioma of the knee joint treated by excision. Following recurrence, it was again excised with removal of the patella, and a course of Coley's toxins was given together with high voltage x-ray therapy. The patient remained well three years. A case of "Synovialoma" (Histioeytoma) was reported by L. La Ferla and G. Demelas⁹ that same year. In 1935, Hodgson and Bishop⁷ reported an interesting case of synovioma of the knee, the patient giving a history of trauma eight months before the discovery of the tumor. High-voltage x-rays and Coley's toxins were tried without benefit. Hydrarthrosis and lymph stasis developed, followed by inguinal adenopathy. Finally, metastases appeared in the skin of the thigh as little shotlike masses which later broke down, draining serous fluid. An excised skin nodule showed the same structure as did one of the inguinal nodes. Death occurred seven months after the onset of the disease.

Since 1900, 24 cases of primary synovial membrane tumors have been observed at the Memorial Hospital. Some of these were merely sections submitted for diagnosis, and because of insufficient follow-up data these are not included in this report. There are, however, 15 cases that have been carefully followed, the detailed reports of which are here given.

CASE 1.—H. M., a forty-five-year-old Austrian cabinet maker, was admitted to the Memorial Hospital, service of Dr. James Duffy, on Dec. 1, 1934. He complained of a swelling on the radial aspect of the left index finger of seven months' duration. There was no particular trauma, although he continually injured his finger while pursuing his trade. Three months after the appearance of the tumor, it was excised, only to recur. Examination disclosed a firm, movable nodule 7 mm. in diameter on the radial side of the first interphalangeal joint. There was moderate tenderness.

A few smaller nodules were found on the dorsum of the finger. Extension was limited to 150 degrees. There was no adenopathy. X-ray films showed a soft part tumor of the left index finger, with no bone involvement.

Pathologic Report.—Of submitted slide, synovioma (Stewart).

Treatment.—Prophylactic irradiation to the left index finger, using a dosage of 800 r. to each of two portals. This was given within a period of eighteen days. *Factors:* 198 K.V. S.T.D. 50 cm. Field: 5.2×5.2 cm.

Course.—Has had 1,600 r. to each of two portals, but tumor continues to grow. Chest film negative for metastases. Patient advised to have amputation, to which he consents. (Jan. 15, 1936.)

CASE 2.—J. C., a nine-month-old male infant, was admitted to the Memorial Hospital in April, 1931, service of Dr. F. E. Adair. When the child was two months old, the parents had noticed a tumor of the left knee mesial to the patella. At that time the tumor was excised, but recurred within one month. Examination revealed a tumor of the left knee extending 4 cm. above and below the patella. There was no bone involvement.

Operation.—Wide excision by Dr. Adair on April 22, 1931. The joint became infected and erysipelas developed, following which the patient made a satisfactory recovery.

Pathologic Report.—Mesothelioma arising in the synovial structures malignant and capable of metastases. (Stewart.)

Irradiation.—Four months postoperatively irradiation was begun, giving 595 r. to each of two portals for a total of 1,195 r. in six months. *Factors:* 198 K.V. S.T.D. 50 cm. Field: 10×10 cm.

Course.—Three years and six months later the chest film was negative for metastasis, and there was no evidence of recurrence. Left leg 2 cm. shorter than the right. Patient was perfectly well and gaining weight.

CASE 3.—V. C., a twenty-four-year-old American student, was admitted to the Memorial Hospital April 13, 1931, service of Dr. Adair. Six months prior to entry he noticed a pain in the heel of the right foot. Ten months later he noticed a tumor in the intermalleolar fossa extending down to the heel. A local excision was done, with prompt recurrence of the tumor. Examination disclosed a scar on the right lower leg 8.0 cm. in length, extending from the side of the heel up to the malleolus. There was no adenopathy. X-ray films showed slight periostitis of the shaft of the fifth metatarsal. A chest film was negative for metastasis; however, on March 14, 1932, nodules interpreted as advanced pulmonary metastases were seen throughout both lung fields.

Pathologic Report.—Of submitted slide, synovioma (Stewart).

Irradiation.—Given 2,520 r. to each of two portals over a period of one year. Also 1,600 r. to chest. *Factors:* Foot: 140 K.V. S.T.D. 38 cm. Chest: 200 K.V. S.T.D. 70 cm.

Course.—Died April, 1932, of pulmonary metastases, two years and six months after first symptom was noticed.

CASE 4.—L. B., a thirty-five-year-old Canadian clergyman, was admitted to the Memorial Hospital January 15, 1934, service of Dr. William L. Watson, complaining of swelling on the plantar surface of the right foot of three years' duration. The swelling had progressed so that in one year it had extended to the dorsum of the foot. It was aspirated in 1932 and again in 1934. Patient experienced severe pain on walking, even when no shoe was worn. Examination revealed a soft tumor, which could be somewhat reduced by pressure, located on the plantar surface of the right foot and extending to the dorsum. There was no adenopathy. X-ray films showed no bone involvement.

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Pathologic Report.—Synovium, capable of metastasis.

Treatment.—On January 15, 1933, given 500 r. \times 2. Patient then left the hospital and returned in two weeks, the pain being greatly relieved. From April 19 to 26, 1934, he was given 600 r. \times 2. *Factors:* 140 K.V. S.T.D. 30 cm. On December 6, 1934, there was slight improvement, but the lesion had increased in size and weight-bearing was painful. Amputation was done at the upper third of the leg. The patient was fitted with an artificial limb and was walking within one month after entrance to the hospital.

Course.—Although the patient is now symptom-free, x-ray films of the chest in March, 1936, showed metastatic infiltration of both lung fields.

CASE 5.—M. S., a twenty-two-year-old American girl, was admitted to the Memorial Hospital September 15, 1933, service of Dr. Adair. Seven years prior to entry she suffered a slight trauma to the dorsum of the left hand, following which a lump the size of a bean appeared. There was no increase in size until fourteen months before entry, when it grew to the size of a hen's egg. Local excision was done twelve months before admission. Examination revealed a hard, fixed tumor on the dorsum of the left hand. There was no tenderness, and no sensory or motor involvement. One year after local excision, two discrete nodular shadows were seen, one just above the right diaphragm, the other on the third interspace. One month later, the patient had a pleural effusion. On Oct. 19, 1933, amputation was done 10 cm. above the wrist.

Pathologic Report.—Malignant synovium or endothelioma.

Course.—Died January, 1935, of pulmonary metastases. Duration of symptoms—four years.

CASE 6.—M. T., a forty-seven-year-old Russian male, was admitted to the Memorial Hospital January 13, 1934, service of Dr. Adair, complaining of painful swelling of the left knee. Two years prior to entry he suffered severe trauma to the knee which soon became swollen and inflamed. Within a week this subsided and he resumed work. Four months after injury he noticed pain and swelling in the joint. Operation was performed, followed by two courses of irradiation of ten treatments each, extending over a period of three months. The patient was well for a year and a half, when he noticed pain on the inner aspect of the knee joint. The leg was placed in a cast for eight weeks, but the pain became more severe. More x-ray treatment was given, without improvement. On examination the knee was tender, shiny, epilated. It was enlarged and irregular in contour, the swelling being hard and confined to the antero-medial aspect of the knee joint. Motion was limited to about five degrees. X-ray films showed marked porosity of the bones of the left knee. There was no tumor of the bone or soft parts. The chest showed metastases. Amputation was done for pain, and the stump was revised twenty-two days later.

Pathologic Report.—A firm, yellow, edematous specimen with flecks of deposited calcium. No gross bone. A tendency to break down into villous cysts. Microscopic diagnosis: malignant synovium.

Irradiation.—Preoperatively 72,000 r. \times 4 to knee. One hundred eighty K.V. S.T.D. 40 cm. At Memorial Hospital he was given two cycles 750 r. \times 3. *Factors:* 198 K.V. 50 cm. *Fields:* 15.6 \times 7.8 cm. Total irradiation to knee 9,450 r. \times 3. To chest 1,600 r. \times 8. Patient died December, 1934, of pulmonary metastases. Duration of symptoms—three years.

CASE 7.—F. G., a thirty-five-year-old Jewish housewife, was admitted to the Memorial Hospital Nov. 1, 1934, service of Dr. Bradley Coley. Eight years before entry she suffered slight trauma to the right knee associated with mild pain. This was accompanied by slight swelling, then disappearance of the pain. One year before admission lamp treatments were given for the swelling. This was followed by an increase in size of the knee and continuous pain. Examination showed the lateral

aspect of the right thigh near the joint to be somewhat swollen, with a tumor measuring 6.0 by 5.0 cm. There was no adenopathy. X-ray films showed a tumor of the soft parts just above the external condyle. There was no bone involvement.

Operation.—In November, 1934, local excision was done and a tumor communicating with the knee joint was removed.

Pathologic Report.—Synovioma capable of metastasis.

Irradiation.—One week postoperatively began with a dosage of 200 r. daily from Nov. 27, 1934, to Jan. 8, 1935, for a total of 2,400 r. \times 3. *Factors:* 198 K.V. S.T.D. 63 cm. Field: 8 cm.

Course.—Patient was perfectly well June 22, 1936. Chest film negative for metastasis. Good function of the knee joint.

CASE 8.—N. C., a twelve-year-old American schoolgirl, was first seen by Dr. Schuyler Pulford in September, 1932. One year prior to observation she noticed a small lump over the left knee, which gradually developed into a painful mass the size of an ordinary lemon. There was no history of injury. X-ray films showed a pressure atrophy of the fibula.

Operation.—A local excision was done in September, 1932, by Dr. Gustav Wilson. At operation a tumor of grayish white soft tissue resembling brain substance was encountered. Following biopsy and exploration, a complete course of x-ray therapy was given, followed by amputation.

Pathologic Report.—Synovioma of low-grade malignancy and capable of metastasis. (L. Smith.)

Course.—Patient is wearing an artificial leg and is perfectly well six years after operation.

CASE 9.—I. S., a sixty-four-year-old white Russian locksmith, was admitted to the Memorial Hospital June 22, 1932, service of Dr. Adair, complaining of a tumor of the right foot of five months' duration. He did not see a physician until one week prior to entry, when he was referred to the Hospital for the Ruptured and Crippled. Examination disclosed a swelling on the inner surface of the foot about the internal malleolus. The only tenderness was on the plantar surface. X-ray films showed no evidence of bone tumor formation. Aspiration biopsy was attempted without success.

Operation.—Local excision was done Aug. 4, 1932.

Pathologic Report.—Spindle cell sarcoma suggestive of bursal or synovial origin. (Despite the report of no radiation, it looks like a treated case. There are abortive cell divisions, infarction, endarteritis, and sclerosis.) Process does not look highly malignant and looks as if it might sclerose with radiation.

Irradiation.—Given 800 r. \times 2 in two days. *Factors:* 198 K.V. 0.5 mm. Cu S.T.D. 50 cm. Field: 8.0 \times 8.0 cm.

Course.—Leg amputated below the knee on Sept. 14, 1932. Slides of this specimen showed the tumor to be a synovioma. Course was uneventful until June, 1934, when the stump began to show changes which appeared to be secondary to arteriosclerosis. In December, 1934, a midhigh amputation was done for arteriosclerotic disease. No tumor was found in this specimen. Films of the chest taken at this time were negative for metastases. The patient was last seen in January, 1936. There was a low grade inflammation in the stump which requires dressings. No evidence of pulmonary metastasis.

CASE 10.—M. P., a twenty-seven-year-old Jewish accountant, was admitted to the Memorial Hospital Sept. 4, 1934, service of Dr. George Pack. Nine months before admission the patient suffered an injury to the right palm with lacerations. The pain of the injury persisted until four months before admission, although baking and massage were used to alleviate it. The swelling that attended this injury persisted and increased until a local excision was done at another hospital three months prior

to admission. One week before admission a second excision was done, and a cystic, well-circumscribed tumor was removed. Examination revealed a healed, transverse incision across the palm, measuring about 3 by 3.5 cm. This traversed a soft, firm tumor mass. The fingers were semiflexed and forced extension caused severe pain.

Pathologic Report.—An aspiration biopsy was negative. A submitted slide from the second operation was reviewed by Dr. Ewing and found to be papillary endo-thelionia of tendon sheath or bursal origin. Grade 11 R.R. (synovionia).

Treatment.—Given 2,500 r. \times 2 within ten days. *Factors:* 198 K.V. S.T.D. 50 cm. Field: 7.8 \times 7.8 cm.

Course.—Tumor is now one-fifth its original size and the patient has good function of fingers. Chest films were negative for metastases Jan. 15, 1936.

CASE 11.—A. H., a sixteen-year-old Jewish schoolgirl, was admitted to the Hospital for the Ruptured and Crippled in November, 1933, service of Dr. William B. Coley. She complained of pain in the left knee of six months' duration. There was no associated trauma. Examination disclosed a freely movable, firm mass, the size of a lima bean, on the medial aspect of the knee.

Operation.—A local excision was done in November, 1933. In February, 1934, there was a recurrence. The patient was again operated upon, a wide excision of the tumor with excision of the patella being done.

Pathologic Report.—Fibrosarcoma of synovial membrane (synovionia).

Course.—In March, 1934, the patient received irradiation with the 4 gram radium element pack at 6 cm., the dosage being 22,000 mg. hr. mesially, and 16,000 mg. hr. laterally (March 25 to 31). When last seen in April, 1936, she was perfectly well, had good function of the joint, and walked without a limp. Chest films were negative for metastases.

CASE 12.—M. D., a forty-five-year-old American housewife, was first seen by Dr. Fred O. Coe on Jan. 8, 1930. One month prior to observation, she complained of a painful swelling over the ball of the left great toe. This was regarded as a bursitis, and the head of the second metatarsal was resected. Two months after operation, several small nodules appeared close to the scar. The patient was given x-ray therapy without effect, and definite recurrence was found in August, 1932, twenty-one months after operation.

Operation.—A local excision was done in March, 1933, and again in August, 1933. The patient was given two x-ray treatments amounting to a full erythema dose.

Pathologic Report.—Synovionia.

Irradiation.—In January, 1934, a small subcutaneous mass was palpable, and within three days 1,200 r. \times 2 were given. Patient received 4,500 r. \times 2 within a period of nine months. *Factors:* 220 K.V. Filter: 1.2 mm. Cu Field: 7.0 \times 7.0 cm.

Course.—When seen in August, 1935, she was perfectly well. Chest films were negative for metastases. Fairly good function of foot.

CASE 13.—M. G., a forty-five-year-old white Hebrew, was admitted to the Lincoln Hospital on July 3, 1935, service of Dr. S. Epstein, complaining of a tumor mass of the left knee. In September, 1932, he noticed a painless lump in the region of the left patella, which slowly grew to the size of a small orange. It was thought to be a lipoma and was excised as such in July, 1933. No pathologic examination was made of this specimen. In December, 1933 (five months after operation), there was a recurrence.

Operation.—In March, 1934, an extensive excision of the tumor mass with a pedicle graft to cover the exposed patella was done. In May, 1935, fourteen months later, there was another recurrence, and the tumor mass was again excised.

Pathologic Report.—Synovionia (Stewart).

Course.—When last seen in June, 1936, the patient was found to have another recurrence; amputation advised.

CASE 14.—J. M., a twenty-nine-year-old Jewish housewife, was admitted to the Memorial Hospital April 1, 1936, service of Dr. W. B. Coley. Nine years prior to entry she noticed pain in the right popliteal space while horseback riding. There was no history of trauma. Two years later a small bean-sized tumor appeared just below the popliteal space. A local excision was done, but a recurrence appeared two years later. Five years ago the tumor was again excised. Owing to involvement of peroneal nerve, foot-drop followed this procedure. One year ago, a second recurrence was treated by wide excision. The patient had been moderately dyspneic for the past four months. X-ray films taken April 1, 1936, showed extensive chest metastases.

Pathologic Report.—Synovioma.

Irradiation.—Patient was given 400 r. units to each of four portals in left chest.

Factors: 198 K.V. 70 cm. Field: 14 × 14 cm.

Course.—Patient died of chest metastases on April 3, 1936.

CASE 15.—F. K., a forty-four-year-old Jewish housewife, was admitted to the Memorial Hospital on Jan. 20, 1936, service of Dr. George Pack. One year before her admission she noticed a painless swelling on the medial aspect of the dorsum of the left foot. There was no history of trauma. Six weeks before admission the tumor was excised, but there was a prompt recurrence which necessitated excision again five weeks later. A pathologic diagnosis of sarcoma was made at another hospital, and the patient was referred to the Memorial Hospital. Examination on entry revealed a painless, infected, fungating tumor on the medial aspect of the left foot, anterior and below the ankle. There was no adenopathy. Films of the chest taken on Jan. 22, 1936, showed no evidence of metastasis.

Pathologic Report.—Synovioma.

Irradiation.—Patient has received 80,000 mg. hr. from Jan. 28, 1936, to Feb. 11, 1936, to one portal (left ankle medially), using the 4 gram element pack at 10 cm. distance.

Course.—On April 4, 1936, inflammation had subsided and the incision had healed, but regression of the tumor had not been satisfactory.

ETIOLOGY

Of the predisposing factors, age is of negligible significance, as is shown by the fact that the youngest in this group was an infant nine months old, while the oldest patient was sixty-four years of age. Race as a factor may be dismissed as having no further bearing on etiology. The sex incidence is, however, of some interest, in that 4 of the 13 cases reported occurred in women, whereas 9, or more than two-thirds, were in men. Stewart³ mentions the possibility that inflammatory changes in a chronic synovitis might be held accountable for the neoplastic development in some of these tumors. In only one of our cases was there a preexisting inflammation that might be considered as a possible etiologic factor. One, of course, cannot say what influence trauma may have had toward inducing inflammatory, hyperplastic, or perhaps neoplastic, changes in 6 of our cases.

SYMPTOMS AND PHYSICAL SIGNS

In early cases pain may be the only complaint. This is described as being dull, aching in character, and is particularly aggravated by weight-bearing. One author suggests that this is evidence of invasion

to admission. One week before admission a second excision was done, and a cystic, well-circumscribed tumor was removed. Examination revealed a healed, transverse incision across the palm, measuring about 3 by 3.5 cm. This traversed a soft, firm tumor mass. The fingers were semiflexed and forced extension caused severe pain.

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Operation.—A local excision was done in March, 1933, and again in August, 1933. The patient was given two x-ray treatments amounting to a full erythema dose.

Pathologic Report.—Synovioma.

Irradiation.—In January, 1934, a small subcutaneous mass was palpable, and within three days 1,200 r. \times 2 were given. Patient received 4,500 r. \times 2 within a period of nine months. *Factors:* 220 K.V. Filter: 1.2 mm. Cu Field: 7.0 \times 7.0 cm.

Course.—When seen in August, 1935, she was perfectly well. Chest films were negative for metastases. Fairly good function of foot.

CASE 13.—M. G., a forty-five-year-old white Hebrew, was admitted to the Lincoln Hospital on July 3, 1935, service of Dr. S. Epstein, complaining of a tumor mass of the left knee. In September, 1932, he noticed a painless lump in the region of the left patella, which slowly grew to the size of a small orange. It was thought to be a lipoma and was excised as such in July, 1933. No pathologic examination was made of this specimen. In December, 1933 (five months after operation), there was a recurrence.

Operation.—In March, 1934, an extensive excision of the tumor mass with a pedicle graft to cover the exposed patella was done. In May, 1935, fourteen months later, there was another recurrence, and the tumor mass was again excised.

Pathologic Report.—Synovioma (Stewart).

Course.—When last seen in June, 1936, the patient was found to have another recurrence; amputation advised.

joints and, so far as we know, no case has been reported in the literature. Adenopathy almost never occurs. It should be emphasized that physical signs are of little aid in the diagnosis, which is determined definitely on biopsy.

TREATMENT

The clinical course of synovioma varies with respect to the histologic features and to the type of treatment employed. Some show a microscopic picture that indicates a low grade of malignancy, while others, with much more malignant features, not only tend to recur promptly, but even give rise to pulmonary metastases.

Irradiation.—While irradiation has been employed, it is generally accepted that these tumors are not radiosensitive. In two of Smith's¹⁵ cases the cutaneous and pulmonary metastases were only temporarily improved. One of Wagner's¹⁷ cases was treated by F. C. Wood for a period before consent to amputation was obtained, and during this time the growth slowly extended into the head of the tibia. Knox⁸ reports a case having pulmonary metastases treated by irradiation with no improvement. Of the Memorial Hospital cases only one showed regression following irradiation. This was a synovioma of the finger that received intensive treatment. Thus far it would seem that for operable cases, treatment solely by irradiation is scarcely justified.

Surgical Excision.—Owing to the fact that the true nature of the process is so seldom appreciated until after the sections have been examined, the initial operation is often undertaken lightly, and the excision may be inadequate. Moreover, the anatomic location of the tumor may make it difficult to remove as much pathologic tissue as desirable. Once the tumor has recurred, it is not likely to yield to further conservative operation, and resort to a radical procedure, such as amputation, is necessary.

Preoperative irradiation followed by excision is not often attempted, since the diagnosis is generally arrived at only after a local removal, and tissue study has been done. At present, it is our opinion that any operable tumor, which, by its location, suggests the probability or even the possibility of synovioma, should have a wide excision. If histologic study confirms this diagnosis, then postoperative irradiation by fractional dose x-ray may be advisable. If the recurrence should follow, an amputation is then in order, provided the lungs are free from metastases. But if the diagnosis has been established, and the local excision is impractical or impossible, amputation seems justified. Where no operation is feasible, or where it is refused by the patient, x-ray therapy or radium pack treatment is suggested.

Our experience with postoperative injections of Coley's toxins for synovioma is insufficient to permit of an expression of opinion as to

of the periosteum, but it should be borne in mind that the synovial lining of joints is very sensitive, and when these structures are inflamed or compressed, severe pain results.

Joint function is often surprisingly unimpaired and bone is not usually involved, so that radiographic examination may be entirely negative. ~ Wagner,¹⁷ however, has called attention to the fact that if films are made for soft tissue detail, the presence of the tumor may be revealed, and this was demonstrated in one of our cases. Knox states that in some cases joint tuberculosis may be simulated. As a rule, physical signs in early cases are of little aid, and the lesion is discovered at operation, which is usually an exploration, its true nature not being suspected until the pathologist examines the tissue.

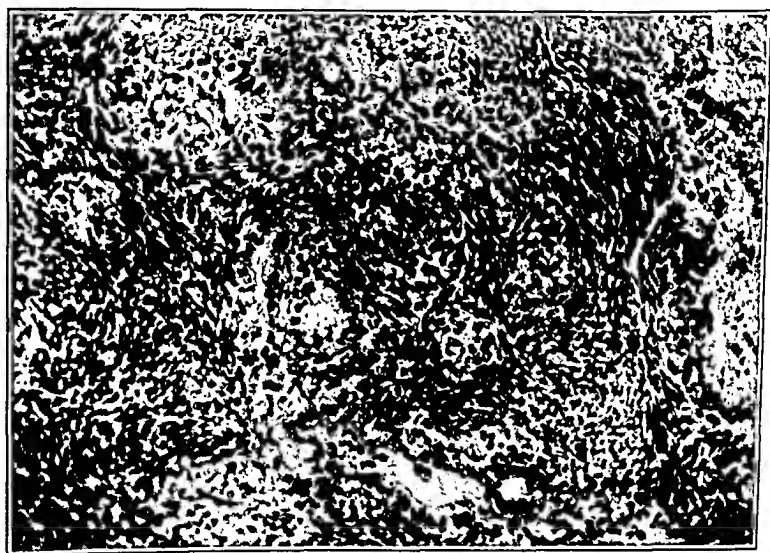


Fig. 1.—Section of synovioma showing typical glandlike structure (X150).

Aspiration biopsy should prove of value in the diagnosis, but so far as we know, it has not been used in any of the cases reported.

DIFFERENTIAL DIAGNOSIS

Diagnosis is often exceedingly difficult. Where no palpable tumor exists, it may be impossible until operation has disclosed the condition. Where a definitely palpable tumor exists, it must be differentiated from other soft part tumors, such as fibrosarcoma, myosarcoma, neurogenic sarcoma, liposarcoma, and xanthosarcoma of tendon sheath origin. The tumor is usually firm, well circumscribed, homogeneous, is not particularly tender, and occurs most frequently near the knee joint. Other joints involved are those of the fingers, ankle, and metatarsus. We have not seen the condition in the hip, elbow, or shoulder

joints and, so far as we know, no case has been reported in the literature. Adenopathy almost never occurs. It should be emphasized that physical signs are of little aid in the diagnosis, which is determined definitely on biopsy.

TREATMENT

The clinical course of synovioma varies with respect to the histologic features and to the type of treatment employed. Some show a microscopic picture that indicates a low grade of malignancy, while others, with much more malignant features, not only tend to recur promptly, but even give rise to pulmonary metastases.

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Our experience with postoperative injections of Coley's toxins for synovioma is insufficient to permit of an expression of opinion as to

their possible value as a prophylactic against recurrence or metastases. The similarity of the lesion to other endotheliomas would suggest that they be given further trial in conjunction with postoperative irradiation. In this connection it may be noted that one of the five-year survivals developed erysipelas while under treatment.

TABLE I
CASES SURVIVING FIVE YEARS OR MORE—MEMORIAL HOSPITAL SERIES

NAME	METHODS OF TREATMENT	FINAL NOTE
J. C.	Local excision; irradiation; patient developed erysipelas	Six-year survival; no evidence of recurrence
M. D.	Local excision; irradiation	Five-year survival; no evidence of recurrence
J. M.	Local excision; irradiation	Seven-year survival; died of pulmonary metastases

TABLE II
COLLECTED SERIES FROM LITERATURE

NAME	METHODS OF TREATMENT	FINAL NOTE
Marsh	Local excision; amputation	Alive
Faulkner	Local excision; irradiation	Alive
Wagner, L. C.	Local excision; irradiation; Coley's toxins; amputation	Dead (ten-year survival)
Knox, L. C.	Local excision; amputation	Dead (six-year survival)
Coley, W. B.	Local excision (3 attempts)	Dead (seven-year survival)

TABLE III
END-RESULTS OF SYNOVIOMA CASES—MEMORIAL HOSPITAL SERIES

NO.	NAME	AGE	SEX	METHODS OF TREATMENT	PERIOD OF SURVIVAL	DEAD OR ALIVE
1	H. M.	45	M	Local excision; irradiation	18 months	Alive
2	J. C.	9 mo.	M	Local excision and irradiation; patient developed erysipelas	5 years	Alive
3	V. C.	24	M	Local excision and irradiation	2½ years	Dead
4	L. B.	35	M	Amputation	4 years	Alive (dying of pulmonary metastases)
5	M. S.	22	F	Local excision and amputation	13 months	Dead
6	M. T.	47	M	Local excision; amputation; irradiation	3 years	Dead
7	F. G.	35	F	Local excision; irradiation	18 months	Alive
8	N. C.	12	F	Local excision; amputation; irradiation	4 years	Alive
9	I. S.	64	M	Local excision; amputation; irradiation	4 years	Alive
10	M. P.	27	M	Local excision; irradiation	1 year	Alive
11	A. H.	16	F	Local excision; irradiation; Coley's toxins	3½ years	Alive
12	M. D.	45	F	Local excision; irradiation	5 years	Alive
13	M. G.	45	M	Local excision	6 months	Alive
14	J. M.	29	F	Local excision; irradiation	7 years	Dead
15	F. K.	44	F	Local excision; irradiation	6 months	Alive

Considering the cases as a whole, we believe that in the past, the early treatment had been too conservative and radical surgery instituted too late in the course of the disease. If treatment were more radical at the outset, the results might be improved.

PROGNOSIS

Of the 20 case reports in our review of the literature, 18 were followed for periods varying from six months to ten years. Of these, 1 survived ten years, finally dying of pulmonary metastases; 4 survived five years, and 3 lived three years. Of the remaining cases, 4 died in less than three years, and the other 6 still survive. Of our patients, only 3 are five-year survivals.

TABLE IV
END-RESULTS OF SYNOVIOMA CASES PREVIOUSLY REPORTED IN LITERATURE

NO.	REPORTED BY	AGE	SEX	METHODS OF TREATMENT	PERIOD OF SURVIVAL	DEAD OR ALIVE
1	Hardie and Salter	25	M	Amputation	1 year	Alive
2	Lejars and R. Duval	22	M	Local excision; amputation	1 year	Dead
3	Marsh	21	M	Local excision; amputation	6 years	Alive
4	Razemon and Bizard	22	M	Local excision (wide)	2 years	Alive
5	Lockwood	24	F	Resection of knee joint	-----	Died (surg. shock)
6	Faccini	—	—	Local excision; amputation	1 year	Alive
7	Wegelin	28	M	Local excision	6 months	Alive
8	Turner	28	M	Local excision	Not followed	
9	Chenot and Tzanek	38	F	Local excision	Not followed	
10	Smith, L. J.	24	M	Local excision; irradiation following recurrence	3 years	Dead
11	Smith, L. J.	35	M	Local excision; irradiation; amputation	2½ years	Dead
12	Wagner, L. C.	35	M	Local excision; irradiations; toxins, amputation	10 years	Dead
13	Wagner, L. C.	15	F	Local excision	3 years	Alive
14	Faulkner	49	F	Local excision; irradiation	6 years	Alive
15	Faulkner	28	F	Local excision	4 months	Alive
16	Knox, L. C.	—	F	Local excision; amputation	6 years	Dead
17	Knox, L. C.	33	M	Local excision; amputation	3 years	Dead
18	Knox, L. C.	24	M	Local excision; amputation	2½ years	Alive
19	Hodgson and Bishop	28	M	Biopsy; irradiation; amputation; Coley's toxins; local excision	7 months	Dead
20	La Ferla and Demelas	17	M	Local excision	3 years	Alive

Combining our results with those in the literature, we have 6, or 20 per cent five-year, and 13, or 40 per cent three-year survivals. We know of none who has survived more than ten years, and therefore can only conclude that with the present mode of treatment, life expectancy is certainly not more than this, while in two-thirds of the patients, it is less than five years.

SUMMARY

A study of reported cases of synovioma and others observed at the Memorial Hospital comprises the 20 followed cases in the literature and 15 in our series. The knee is the most frequent site. No single etiologic factor is apparent. The diagnosis is seldom made until biopsy reveals it. There is a wide variation in the degree of malignancy, rapidity of dissemination, and life expectancy.

Treatment thus far has been very disappointing. These tumors are radioresistant. We do not favor preoperative irradiation. Amputation is recommended unless wide excision is still practicable, and for recurrence, unless a second more radical excision seems feasible. Toxin injections may be tried as a prophylactic measure in addition to surgery and postoperative irradiation. Thus far early treatment has been too conservative, rendering later radical measures ineffectual.

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Editorials

Carcinoma of the Lung

THE introduction and employment of a new technique or of some new method in the treatment of any given disease never fail to create a renewed interest in that syndrome, although for many years its pathologic basis may have been recognized. In this way any new diagnostic or therapeutic measure is, as a rule, responsible for what might be termed "a wave of increase" in our comprehension of many disease syndromes. It is so often true that our knowledge of some well-known clinicopathologic entity remains stationary until some new diagnostic or therapeutic measure is invoked which renders possible the successful treatment of previously unsatisfactory cases. Thus, it may be said that medical history is at the present time repeating itself in regard to the diagnosis and treatment of carcinoma of the lung, and it is of interest to note that in the last three years a renewed enthusiasm in dealing with this condition has been awakened. One need only refer to the earlier textbooks on medicine and, although to a much less extent, on surgery, to realize that formerly the diagnosis of carcinoma of the lung was practically never made until extrapulmonary extension of metastases was clinically recognized and the morbid process was too far advanced to contemplate or justify anything more than simple palliative treatment.

As a matter of fact, most of the symptoms and signs which have been attributed to carcinoma of the lung in reality have been due to carcinoma of the structures involved by regional and remote extensions of the growth from the site of its primary origin. In other words, the clinical syndrome described by earlier writers has consisted of signs and symptoms referable not only to involvement of the lung itself but also to lesions in the surrounding structures and organs. Naturally, then, the correct diagnosis was never or hardly ever made until the disease was obviously incurable by any means or methods known in former times.

In the last few years, however, improvement in our diagnostic methods as well as in our operative technique now renders it possible not only to make an early diagnosis of malignant pulmonary tumors but also to remove a portion or the whole of the lung from a patient in whom such an early diagnosis of malignant tumor has been made, and as a result the clinician can find at the present time more than

mere academic interest in making an early diagnosis of malignant tumors of the lung or other neighboring structures. The increasing number of successful operations performed and reported in the surgical and medical literature for the removal of the lung for carcinoma bears witness to the prompt and enthusiastic response on the part of the clinician to this therapeutic advance. Medicinal and radiation therapy had provided measures of relief, but for many cases these were only temporary and in some of no value at all.

In the past, the occurrence of hemoptysis was considered, in the great majority of cases, to be due to pulmonary tuberculosis until proved to be otherwise, whereas at the present time the presence of blood in the sputums calls for an immediate and careful examination by various modern methods. In other words, at the present time the burden of proof is now on the man who says that this blood spitting is due to tuberculosis and is not a manifestation of growth in the lung. Our clinical pace must be quickened, for until recently the great majority of recognized affections of the respiratory tract have been those in which Time was felt to be the Great Healer, but with the development of methods by which patients cannot only be relieved but cured of malignant neoplasms of the lung it may be said that Time now takes on the rôle of executioner. Successful surgical treatment of carcinoma of the lung depends on an early diagnosis, for malignant tumors in this region masquerade very often as inflammatory affections, specific or nonspecific, and are often hidden under the guise of less serious conditions.

It should also be noted that due to the movement of the entire organ throughout the respiratory cycle, neoplasms arising in the smaller bronchioles or the parenchyma of the lung itself are likely to be disseminated throughout the body at a rather early stage because of the constant motion or milking action or respiratory massage of the growth. While it is true that growths of the primary bronchi in which there is little if any motion are rather slow growing and perhaps late in metastasizing, quite the opposite condition prevails in the tumors arising in the periphery of the lung.

The successful treatment of carcinoma of the lung does not differ in any way from the successful treatment of carcinoma elsewhere in the body. The sine qua non of the proper treatment of malignancy consists in total removal of the organ involved with its attendant lymphatic glands. The lung, like the breast, is an organ which can be removed in its entirety without incapacitating the individual upon whom the operation has been performed. The absence of one lung is not incompatible with a vigorous and active life, for there occurs a compensatory dilatation of the remaining lung which restores the pa-

tient's cardiorespiratory balance almost to its preoperative state. Partial pneumonectomy or lobectomy for carcinoma of the lung has been advocated by some, and unquestionably lobectomy must be taken into consideration when the condition or age of the patient may discourage the idea of a total pneumonectomy, or in case it is thought advisable to perform the total pneumonectomy in two stages. In this manner it may be possible and advisable to remove the affected lobe in the first stage through one incision or approach, and later through an entirely different incision remove the remaining lobe or lobes and the mediastinal lymphatic glands, the condition of the patient being "built up," as it were, between stages.

The removal of one lobe at a time presupposes, of course, that the location of the new growth is in a position far enough removed from the hilus of the lung to permit such an operative procedure. If, on the contrary, the tumor is situated well up in the primary bronchus toward the bifurcation of the trachea this type of a two-stage operation cannot be performed. At the present time in practically all patients over forty-five years of age, a more ideal type of multiple stage total pneumonectomy is employed. This procedure consists, in the first stage, of the ligation of the main branch of the pulmonary artery, either the right or the left, depending on which lung is to be operated upon, before it enters the hilus. Following this any adhesions present are divided as well as the pulmonary ligament up to the level of the inferior pulmonary vein. The chest is then closed with the entrapped air. After one to three weeks, or as soon as the patient's pulse, respirations and temperature have returned to normal, the thorax is reopened through the same incision and the lung is removed. In this manner time is provided for the patient to become adjusted to postoperative changes in the circulatory as well as the respiratory mechanisms. The circulation through the bronchial artery and pulmonary veins prevents the occurrence of gangrene of the lung. There is thus brought about a marked shrinkage in volume of the lung which becomes nonair-containing and relatively avascular. The secondary amputation of the entire organ is thus facilitated for the operator and is much less of a shock for the patient. This method of a multiple stage total pneumonectomy permits the gradual readjustment of the patient as a whole to the changed intrathoracic conditions brought about by throwing one entire lung out of function. This adjustment of the patient as a whole includes many imponderables involving the cardiorespiratory mechanism which are unknown at the present time, but also includes some obvious mechanical alterations which can be observed; i.e., the elevation of the diaphragm on the operated side; the gradual and slight shifting of the mediastinum toward the operated side; the approximation of the ribs with the re-

sultant diminution of the thoracic cage; and finally the decrease in the diameter of the primary bronchus to the operated side as a result of disuse atrophy. All of these factors tend to minimize the danger of the final amputation of the lung and at the same time expedite the obliteration of the remaining thoracic dead space and the healing of the primary bronchus. On account of the greater embarrassment resulting from sudden rotation and displacement of the heart to the right than to the left side of the chest, this type of multiple staged procedure is particularly well adapted to total right pneumonectomy. The method is a safe procedure for older individuals and may in the end prove so for all ages. The first-stage ligation, and pneumolysis if necessary, does not in any way, as in so many instances in surgical two-stage operations, complicate the second stage. On the contrary the latter is made far more simple.

The many ways by which a malignant tumor of the lung may extend is well known. The incompleteness of the fissures between the lobes of the lung renders it highly improbable that a malignant tumor large enough to be detected by an x-ray shadow out in the periphery of one lobe of the lung would be confined solely to that lobe. Therefore lobectomy in such a case would be harmful rather than beneficial to the patient, whereas in this type a total pneumonectomy might readily afford a complete cure. If, on the other hand, the tumor is located in the primary bronchus or close to this region, it will more than likely be anatomically impossible to remove it unless a total pneumonectomy is performed. The lymphatic glands cannot be properly dissected out from the primary bronchi or mediastinum unless a total pneumonectomy is done. The lobes of the human lung are not completely separated and therefore when it be said that a so-called "lobectomy" has been performed, what is meant is that a partial lobectomy or, better still, a partial pneumonectomy was done. This, of course, is not by any means the ideal type of operation for the cure of a malignant tumor of the lung, because the part of the affected lobe left behind is that portion toward which the lymphatic vessels drain. The parenchyma of the affected lobe remaining may also be invaded, although this cannot be determined in the gross by palpation. The same may also be applied to total pneumonectomy. Total removal of the lung means that the entire organ has been removed; i.e., that the primary bronchus has been divided before entering the hilus of the lung, and that the pulmonary artery and veins are likewise ligated individually before entering and after departing from the pulmonary parenchyma. When a tourniquet or temporary ligature has been applied grossly to the entire pedicle and the lung allowed to slough off, or when the operator has cut through lung tissue distal to the tour-

quet thus leaving behind a stump of lung, the extent of which varies or is unknown, such cases should not and will not be classified in the final adjudication as instances of total pneumonectomy. Such a procedure is not only unsurgical from a technical standpoint, but is almost certain to be attended by a prompt recurrence of the disease process. The patient is thus not only subjected to an unnecessary operation without hope of cure but also loses the one chance for relief which a careful dissection of the mediastinal glands together with the removal of the entire diseased organ may afford. It may therefore be stated with confidence (a) that total pneumonectomy is certainly the operation of choice for the cure of the patient with primary carcinoma of the lung; (b) that if a multiple-staged operation seems advisable the more desirable procedure would apparently consist as a first stage; the preliminary ligation of the pulmonary artery to the affected side, together with the freeing of the lung from any existing adhesions, as well as division of the pulmonary ligament; reserving amputation of the primary bronchus and division of the pulmonary veins for the second stage.

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The Improper Use of the Word "Drain"

THE word "drain" has been variously defined as "a tube used to promote the escape of fluids from an abscess or wound," to that of "a tube providing a channel for the escape of fluid from a viscus such as the urinary and gallbladder or from the thoracic cavity." A tube inserted into the stomach or jejunum for feeding purposes might also be included as well as an enterostomy or colostomy tube for the removal of fecal material proximal to an obstruction of the bowel. The term "drain" becomes even more confusing when applied to the various tissues and combinations of gauze with rubber or gutta-percha containers that are used in the abdominal cavity to localize or cause to be isolated a certain area of infection, inflammation, or postoperative region that it is felt desirable to have "walled off" from the remainder of the abdominal cavity. From the construction of these various setons or wicks alone, the inappropriateness of the term "drain" is obvious. The only fluid that can escape through them will be a small amount by capillary attraction, "blotted up," so to speak, by the gauze for the first few minutes or hours following their employment. After this short period they become perfectly inert foreign bodies which, by their shape and size, result in the formation of a sinus tract by preventing tissue from interceding between the area to be isolated

and the exterior of the abdominal cavity. These structures do not permit fluid to escape through them as a true drain should. It is felt, therefore, that these wicks should be referred to as "*isolaters*" or "*localizers*" to be distinguished from a true drain. This point is made not only for the sake of academic or scientific accuracy but also because it implies at once the fundamental reasons behind the different uses of the isolater and the drain which not only may aid in the more proper teaching of future surgeons but also may improve the selection of various materials at present used for the accomplishment of isolation in the abdomen.

—*William F. Rienhoff, Jr.*

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

RECENT ADVANCES IN NEUROSURGERY

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Part I

INTRODUCTION

Die Hirnchirurgie hat der gemeinsamen Arbeit von Anatomen, Physiologen und Neurologen einen ungeahnten Aufschwung zu verdanken. . . .

—Fedor Krause, 1908.¹

By slow processes we have come to broaden our horizon, but we do not for a moment forget that we are merely standing on the clustered shoulders of those here unnumbered and unnamed persons who laboriously worked out for the benefit of our generation the development and finer anatomy of the brain, who discovered the localization of its functions, untangled the pathways of its impulses, determined the clinical expression of its lesions, bequeathed to us the instruments we depend upon, laid the foundation stones of modern craniocerebral surgery and more besides.

—Harvey Cushing, 1926.²

NEUROSURGERY is still a youth among the medical and surgical specialties, and, as such, its development continues to be rapid, its complexion to change almost from day to day. Brilliant investigation, bringing newer knowledge; improved diagnostic adjuncts; valuable technical methods; careful studies of large series of cases—these things and others steadily broaden the scope and improve the accomplishments of neurosurgery. While this paper deals primarily with some of the more recent of these developments, it is fitting that a brief tribute be paid to those stalwart forbears without whose abilities and efforts neurosurgery could not have attained its present stature.

Its ancestry extends into antiquity, but neurosurgery is essentially a child of the twentieth century. It inherited from Magendie and Pacchioni, from the Munros and Astley Cooper, from Virchow and Oppenheim and Charcot and a host of others. The first fetal heartbeats became perceptible with McEwen's attack on brain abscesses in the

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1880's, and labor definitely set in with the early operations of Godlee and Horsley and Keen (while anxious accoucheurs like Bennett and Gowers directed the labor!), but with the later days of Victor Horsley in England and the early days of Harvey Cushing in America, neurosurgery may truly be said to have been born.* A few others soon joined in contributing to its development, and gradually its growth became more rapid, its field of interest wider, its adherents more numerous. Most of these early neurosurgeons have continued to make valuable contributions to the subject, and many of these will presently be mentioned.

To include in this brief article all of the valuable and important papers even of the last few years is manifestly impossible. The material included has been selected with the purpose of giving the non-neurosurgical reader a broad view of modern clinical neurosurgery by pointing out the established improvements it has made in recent years. It is obviously true that many interesting cases have been reported, much valuable experimental work done, and numerous operative procedures, whose worth will be proved in the future, have been proposed. Many such important papers have of necessity been omitted.

I. NEUROPHYSIOLOGY AND NEUROLOGIC DIAGNOSIS

In the vast literature on recent neurophysiologic research, investigations in several laboratories and clinics on two subjects bear particularly great clinical diagnostic importance. One group of studies is concerned with the broad significance of, and the localization of function in, the autonomic nervous system, the other with the functions of the cerebral cortex, and particularly of the frontal lobes.

As the culmination of a brilliant series of investigations, Cannon^{6, 7} revived Claude Bernard's⁸ long-overlooked concept of the milieu intérieur, the "internal environment" of the body. Cannon showed that this complex internal mechanism is primarily under the direction of the autonomic nervous system† and, secondarily, of the endocrine glands. He proved that the automatic protective phenomena associated with emotional disturbances (such as the pilomotor stimulation of rage or fear) are directly dependent on the autonomic system, and he called the harmony autonomically maintained in this automatic internal mechanism, "homeostasis."

Meantime, Cushing, long interested in the hypophysis, began to assemble evidence, clinical and experimental, pointing to the existence of a suprahypophyseal (hypothalamic) parasympathetic center, or centers, apparently directly under the influence of posterior hypophyseal secretion. Conversely, this hypothalamic area appeared to

*Adson¹ calls McEwen the "father" of neurosurgery, and Cushing² states that Horsley's famous operation for cord tumor marks its birth.

†An interesting account of the early history of knowledge of the autonomic nervous system has recently been published by Shekell.³

exert direct neural influence upon the hypophysis. In support of this concept were the previous observations suggesting a "portal" circulation from pituitary to hypothalamus of Popa and Fielding,^{10, 11} and the experiments of Beatty^{12, 13} and his coworkers on the visceral effects of stimulation, or destruction of the pretuberal hypothalamic nuclei. Cushing's papers on this subject¹⁴⁻¹⁶ were finally published together in a volume entitled "Pituitary Body, Hypothalamus, and Parasympathetic Nervous System."¹⁷ The subsequent observations of Watts and Fulton,¹⁸ and Hoff and Sheehan¹⁹ upon the visceral effects of anterior hypothalamic lesions were in accord with the hypothesis just described. Similarly, the observations of Bard,²⁰ and Beatty,^{12, 13} a more recent careful series of studies from Ranson's²¹⁻²⁷ laboratory, and important investigations by Keller,^{28, 29} Fulton and Ingraham,³⁰ and many others (see Fulton,³¹ Bard,³² and the papers cited above) have even more definitely proved the existence of centers for sympathetic control in the hypothalamus (probably in its posterior nuclei).

Thus, it has been experimentally established that in the hypothalamus lie subcortical autonomic "centers" which influence or control cardiac and vasomotor function, gastrointestinal and other abdominal visceral function, endocrine function, temperature regulation, sleep, and similar phenomena of the "internal environment." Cushing's revival of the concept of a possible neurogenic basis of peptic ulcers¹⁶ introduces only one of the widespread and fascinating problems upon which new light has been thrown.

Clinically, this localization of autonomic function has been supported by the cases reported by Cushing,¹⁷ Penfield,³³ McLean,³⁴ Masten and Bunts,³⁵ and Davison and Selby.³⁶

The second great series of physiologic studies, that dealing with the functions of the frontal lobes, has emanated largely from Fulton's Laboratory of Physiology at Yale. Conducted almost exclusively on primates, these experiments are remarkable for their carefully planned completeness, as well as for their important physiologic discoveries. The results of this work were summarized in a symposium³⁷⁻⁴¹ at the Cleveland Meeting of the American Medical Association in 1934 and in Fulton's Beaumont and Ludwig Hektoen Lectures.^{42, 43} On functional and structural grounds,^{37, 44, 45} the frontal lobes are divided into the "motor area" (motor cortex, area 6 of Betz cells, area 4 of Brodmann), the "premotor area" (prefrontal area), and the functions of each have been carefully studied. In brief summary, the motor area is the cortical center for direct voluntary control of simple movements, and its destruction results in flaccid paralysis and the signs of Babinski and Chaddock.⁴⁶ The premotor area controls complex integrative muscular movements⁴⁷ and is the cortical center for many autonomic func-

tions (such as vasomotor control⁴⁰ and intestinal movements^{41, 48}). Its destruction produces spasticity, loss of complex movements, temporary "forced grasping,"⁴⁹ and vasomotor disturbances.³⁸ The frontal association area is concerned with intellectual function. It is of great interest that the impairment of this function (especially loss of recent memory and inability to learn) is dependent upon destruction of the prefrontal area on both sides.³⁹

This localization of function has been opposed by Walshe,^{50, 51} but has gained clinical support from Spurling,⁵² Penfield and Evans,⁵³ Kennard, Vicks, and Fulton,⁵⁴ German and Fox,⁵⁵ Brickner,⁵⁶ and Bucy.⁵⁷

Space permits only brief mention of the valuable studies on the visual mechanism by Poljak,⁵⁸⁻⁶⁰ Spence and Fulton,⁶¹ Penfield, Evans and McMillan,⁶² Ranson, Magoun and their coworkers,⁶³⁻⁶⁷ and Merritt and Moore.⁶⁸ The interesting observations on the electric potential discharge from the cerebral cortex by Berger,⁶⁹ Adrian and Matthews,⁷⁰⁻⁷² Cazzamalli,⁷³ Gibbs, Davis and Lennox,⁷⁴ Foerster and Altenburger⁷⁵ and the studies of Elsberg and his associates^{76, 77} on the sense of smell give promise of valuable clinical usage.

The description of the syndrome of pituitary basophilism by Cushing^{17, 78} has opened a new and still controversial problem in the field of endocrinology.

Other diagnostic studies will be discussed in the following sections.

II. ROENTGENOGRAPHY

Roentgenography has long been an essential adjunct to neurosurgical diagnosis. Plain stereoscopic views of skull and spine show evidences of increased intracranial pressure, of local changes in the skull and spine, and of intracranial calcification (*cf.* Davis⁷⁹ and Sosman⁸⁰). The "pineal shift" (Naffziger⁸¹) serves to lateralize many expanding lesions, and Camp, Adson and Shugrue⁸² have demonstrated important roentgenographic changes in the spine which are associated with spinal tumors.

The introduction of ventriculography and encephalography by Dandy⁵³⁻⁵⁶ in 1918 further enhanced the value of roentgenography to the neurosurgeon. Ventriculography was almost universally adopted at once, and many papers concerning it have been published (*e.g.*, Grant,⁸⁷ Pileher and Wilson,⁸⁸ Davis,⁷⁹ Adson,⁸⁹ Fincher,⁹⁰ Elsberg and Silbert.^{91, 92} In 1933, Jessen,⁹³ and Schoenfeld and Freeman⁹⁴ independently reported the use of an opaque medium (thorium dioxide) for ventriculography, and the latter authors subsequently supplemented their first paper by reporting the use of the method in "about twenty cases."⁹⁵ Meanwhile, Twining and Rowbotham⁹⁶ (1935) reported the same procedure in two cases, without apparently being aware of its previous use. That the method is not without

danger, however, is shown by the reports of Shih and Jung,⁹⁷ who experimentally produced thrombocytopenic purpura by the intravenous injection of thorium dioxide in rabbits, and Alexander, Jung and Lyman,⁹⁸ who found ependymal inflammation after its introduction into the ventricles.

Encephalography following spinal air injection had been relatively little used (especially in this country) until interest in it was renewed by Pancoast and Fay^{99, 100} in 1929. Its value has been greatly increased and its use popularized by a recent series of studies by Dyke and Davidoff,¹⁰¹⁻¹¹⁰ who have delineated normal structures and pointed out important diagnostic encephalographic findings.

A recent innovation is cerebral arteriography, introduced by Egas Moniz,^{111, 112} of Lisbon, in 1927. In this procedure, an opaque substance (Moniz first used strontium bromide or sodium iodide, but has recently advocated colloidal thorium dioxide¹¹³) is injected into the internal carotid artery, followed at once by the rapid exposure of a series of skull films. Moniz and his associates have published numerous papers on the subject in several languages.¹¹⁴⁻¹¹⁹ They have recently reported the injection of thorotrast into both carotid arteries at the same time.¹²⁰ Dott,¹²¹ and Worms and Bretton¹²² have used the method, and Lohr and Jacobi^{123, 124} have advocated combining arteriography with pneumoencephalography.

The present field of usefulness of cerebral arteriography must be considered limited by its potential danger, its difficulty of interpretation, and its restricted visualization of intracranial structures.

III. OPERATIVE NEUROSURGERY

The highly specialized technic of craniocerebral operations, still adhering to the early principles of Cushing, Kransse, Frazier, and their contemporaries, has, nevertheless, developed remarkably during recent years. Outstanding among the many contributions has been the introduction by Cushing^{125, 126} of the high frequency, damped-wave electro-surgical unit devised by Bovie.¹²⁷ By facilitating hemostasis and making possible bloodless incision of cerebral tissue, this device has greatly added to operative ease, speed and safety. Other improvements in general operative technic have been the "myoplastie" operation of Penfield and Cone,¹²⁸ the scalp clips of Adson and Fincher,¹²⁹ the incisions for unilateral and bilateral transfrontal exploration of Sachs,^{130, 131} the exposure of the facial canal of Tremble and Penfield,¹³² Naffziger's orbital decompression for exophthalmos,¹³³ and combined occipitocerebellar exposure,¹³⁴ and the delayed nerve-graft method of treating facial palsy of Ducl.¹³⁵ Excellent descriptions of general operative technic have been written by Adson,³ Sachs,¹³⁶ Dandy,¹³⁶ and others.

New operations have been devised for the treatment of many special conditions and these will be discussed in succeeding sections.

IV. NEUROPATHOLOGY

During the past ten years, enormous strides have been made in the field of neuropathology, based largely upon the brilliant development of metallic staining methods by Ramón y Cajal and his pupils.¹³⁷ In 1926, appeared the now classical monograph by Bailey and Cushing,^{138*} in which the gliomas were classified on a histogenetic basis. It was shown that the different types of glioma varied greatly in their most frequent sites of origin, their rapidity of growth, their amenability to surgical removal and in the survival periods of their victims. Thus, it became possible in many cases to make presumptive preoperative and accurate operative histologic diagnoses, to vary the operative procedure with the type of lesion encountered, saving many patients from useless, mutilating operations, and to predict the likelihood and probable time of postoperative recurrence and the susceptibility of the tumor to roentgen therapy (cf. Section VII).

Numerous studies of the various glioma types have further simplified and clarified the classification. Among these may be mentioned the papers of Globus and Strauss¹⁴¹ on spongioblastoma multiforme (now called glioblastoma),† of Bailey and Cushing^{142, 143} on the medulloblastomas, of Cushing¹⁴⁴ on the cerebellar astrocytomas, of Bailey and Eisenhardt,¹⁴⁵ and of Pileher¹⁴⁶ on the spongioblastomas, of Bailey and Bney¹⁴⁷ on the oligodendrogliomas, of Bailey,^{148, 149} and Fincher and Coon¹⁵⁰ on the ependymomas, and of Horrax and Bailey,^{151, 152} on the pinealomas. Beautiful illustrations of the gliomas have been published by Bailey,^{153, 154} and Roussy and Oberling.¹⁵⁵ Kernohan^{156, 157} has made important contributions to our knowledge of spinal cord gliomas.

In a similar manner, the pathologic nature of the fibroblastic tumors arising from the leptomeninges and the cranial nerve sheaths has been carefully studied by Penfield,^{158, 159} Cushing,¹⁶⁰ Phemister,¹⁶¹ Roussy and Cornil,¹⁶² Rhoads and van Wagenen,¹⁶³ Craig,¹⁶⁴ Kolodny,¹⁶⁵ and Bailey and his associates.¹⁶⁶⁻¹⁶⁹ The pathology of the tumors of the blood vessels of the brain has been fully discussed by Cushing and Bailey,¹⁷⁰ and by Dandy.^{171, 172} Space does not permit mention of the many papers dealing with less common tumors. They are discussed in detail in Penfield's monumental "Cytology and Cellular Pathology of the Central Nervous System,"¹⁷³ which was published in 1932 and contains contributions by internationally recognized authorities on the various subjects. An excellent monograph on neuropathology has also been published by Freeman.¹⁷⁴

In addition to the rapidly advancing knowledge of the pathology of tumors, equally important contributions have been made regarding

*It must not be forgotten that previous tentative classifications had been proposed in England by Greenfield¹³⁹ and in France by Roussy, Lhermitte, and Cornil.¹⁴⁰

†This paper preceded the publication of the monograph of Bailey and Cushing.

the reaction of the brain to inflammation and injury by Penfield and his associates.^{159, 175-178} The peculiar pathology of subdural hematoma has been greatly clarified by the studies of Putnam,¹⁷⁹ and Munro and Merritt.¹⁸⁰ (Also cf. Sections VI, VII and IX.)

Two new methods of pathologic examination have been introduced into the study of intracranial tumors; namely, tissue culture by Kredel,^{181, 182} Buckley,¹⁸³ and Russell and Bland,¹⁸⁴ and the supravital preparation by Eisenhardt and Cushing.^{185, 186} The latter is a valuable supplement to the previously employed frozen section method of immediate histologic diagnosis at operation.

(Part II will appear in the next issue of SURGERY.)

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Review of Recent Meetings

REVIEW OF THE SIXTH CONGRESS OF THE INTERNATIONAL SOCIETY OF UROLOGISTS

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THE Sixth Congress of the International Society of Urologists was held in Vienna on September 8 to 12, 1936, with a fair representation of members from 33 different nations, despite the unsettled condition of the world. There were present no Spaniards or Russians, and only 14 of the total American membership of 50. However, the international committee has increased the number of representatives for the United States to 75 (probably because of the prompt payment of dues in the past, the surety of which, together with that of Great Britain's members, has been accredited with keeping the international society alive). Membership in the American Association of Genito-Urinary Surgeons has been held by the national committee as a requisite to admission to the international society and with the extension of this privilege to the association's entire membership, a larger representation at the international meetings will undoubtedly result. Few Americans and Britishers, however, are linguists, while other nationalists, as a rule, know one language or more besides their own. The official languages are English, French, German, Italian, and Spanish. The English-speaking factions, thus handicapped, have been unable to exert the influence in the management of the international society to which they are entitled by reason of the proportion of members who attend, pay dues, and have scientific attainments. The disaffection occasioned by this state of affairs has even led to the agitation for the formation of an international society of English-speaking urologists. This somewhat ridiculous outcome was forestalled by the advent in London of the Clinical Society of Urologists, organized similarly to the American society of that name, the two proposing to hold a joint session just before or after the international meeting. (The first joint session was held in London on September 3 and 4, 1936.) Furthermore, the English language has not fared too badly lately since London had the Congress in 1933 and New York will have it in 1939.

On the last day of the Congress, members select, by majority vote, the three main subjects for discussion at the next Congress and the nation in which the Congress is to be held. Each subject is presented by three essayists so that each Congress has nine chief essayists. The country holding the Congress is permitted one essayist for each subject and the remaining six are selected by nation, the membership of which then chooses its representative; no nation, with the exception of the one acting as host, is permitted more than one essayist. Every member of the society, however, may discuss one, two, or all three subjects after their presentation by the three essayists. Since meetings are held every third year, this arrangement gives ample time for preparation (the rule of 3: 3 subjects, 3 essayists, 3 years) and before the meeting the nine chief papers are printed, in the language of delivery, with summaries translated into the four alien tongues and reach the hands of members as a bound volume. This should permit the discussions to be live and pertinent. Unfortunately, often they are neither. To the average member who understands well only his own spoken language, discussions other than those in that language are useless.

since these discussions do not appear in the published transactions. The free use of lantern slides would help, as many who miss the spoken word could understand the written captions. Such a plan is feasible because these discussions usually are prepared in advance of the meeting and are rarely extemporaneous. As matters stand now, it would seem that the member who reads the transactions at home gets as much scientifically as the one who travels long distances to attend. This is true, except for the value of meeting contemporaries whose scientific publications have been read and whose views and conclusions therein presented have been pondered. First-hand acquaintanceship gives the stamp of authority to an impression gained by reading, and the honesty and sincerity—or the superficiality—of the author is established. For his own education, every member should attend at least one meeting, and subsequent attendance may be guided by social rather than scientific benefits, unless he is urged on by actual participation in the program. That it works this way is proved by the fact that four members from the United States who journeyed to London expressly for the clinical meetings there preferred returning home or sight-seeing to going to Vienna. Nevertheless, the scientific value of the International Congress is very great and all meetings since 1919 have been well attended and successful.

The three subjects presented at Vienna were: I, *Die Behandlung des Prostatacarcinoms* (The Management of Carcinoma of the Prostate); II, *Eiterungen des Nierenparenchyms* (Suppuration of the Renal Parenchyma); and III, *Physiologie und Pathologie der Nierenexkretion* (Physiology and Pathology of Renal Secretion).

I. Carcinoma of the prostate occurs much more frequently than shown by earlier statistics. The incidence has long been placed as 20 per cent of all cases of prostatism. It is probably more than 30 per cent. This apparent rise is caused not by a true increase, but by the more frequent recognition of cancer. This is particularly true of lesions unsuspected on rectal palpation, the tissues of which show cancer on examination after transurethral resection for supposedly benign median bars and hyperplasias or after surgical enucleation (perineally or suprapubically). Cancer has long been known to occur in two forms: either as a primary condition of the true glands of the prostate, or as a malignant degeneration of the periurethral glands after they have undergone hyperplastic changes. The first form has long been thought to arise mostly in the posterior lobe and gives the sensation of stony hardness on rectal palpation. The second form usually gives no clinical evidence of its presence, the obstructive symptoms being referred, rightly as a rule, to mixed and nonmalignant fibromyoglandular changes. The incidence of the two forms and their pathogenesis have not been well understood.

Hryttschak (Vienna, Reporter for Austria), in collaboration with Bauer, made a careful histologic study of the material removed at 310 prostatectomies for hyperplasia. In 108 of these specimens the tissues were found to be normal but there were areas of regeneration and inflammation in 13, areas of regeneration alone in 34, and areas of atypical regeneration in 67 which took on the appearance of precancerous changes in 20 and true cancer in 24. In the 100 of these 310 specimens which were accompanied with complete clinical notes (personal cases), cancer was found histologically in 12, though it had been suspected clinically in only 4. In 7 others, of the 100 specimens (personal), definite precancerous changes were present. Of the 210 specimens of hyperplasia from outside sources, 12 showed cancer and 13 precancerous lesions. Foci of tubular regeneration, which presumably follow an injury either traumatic or inflammatory, were frequently seen in hyperplasia. When tubules had evidently undergone several regenerative changes, by reason of repeated or continual irritation, these changes had become irregular and atypical so that the authors believe that they saw (demonstrated by photomicrographs) the pathogenesis of cancer

in prostatic hyperplasia. This is identical, they believe, with that of cancer in the true glands of the prostate (such as the nonhyperplastic posterior lobe) and in no case was it an extension of this latter into the hyperplasia. The progressive changes are: inflammation—regeneration (which becomes irregular and atypical on too frequent repetition and then potentially malignant)—precancer—cancer. This theory, they believe, explains the peculiar varieties of prostatic cancer (adenomatous, medullary, scirrhous, and squamous cell), the development of cancer many years after prostatectomy and the occurrence of cancer more than twice as frequently in the true prostatic glands as in the hyperplastic portions of the periurethral glands. It establishes the idea, however, that cancer can occur in any portion.

Nitch (London, Reporter for England) discussed "the conservative treatment of carcinoma of the prostate" under three headings: **Irradiation Therapy, Surgery, and Surgery Combined With Irradiation Therapy.** He regards radium implantation as superior to x-ray therapy, the late results of which are disappointing and which may even cause rapid dissemination of the growth. He applied radium in large doses, 14 mg. to the rectal surfaces, 50 mg. to the vesical surfaces, and 5 mg. to the urethral surfaces and in the few patients thus treated obtained a cure in 28 per cent. Suprapubic drainage, transplantation of the ureters and transurethral resection, he listed as conservative methods of surgical treatment. Curative surgery by radical prostatectomy was admitted to be the ideal but is rarely applicable. He transplanted ureters into the rectum for palliation in two patients and prefers this method to drainage by cystotomy. He concluded that "in the future electroresection followed by some form of radiotherapy will be the method of choice."

Oreja's (San Sebastian, Reporter for Spain, paper read by title) printed discussion is mostly statistical, from the literature, reiterating the well-known fact that cure depends on early recognition and radical removal, and the perineal route is the method preferred by the majority.* Cancer of the prostate is so insidious and slow-growing that statistics from different sources on the relative merits of methods of treatment are not really comparable. Patients have been known to live for twelve or more years after a definite diagnosis of cancer, with no treatment whatsoever. Reports of three-, four-, and five-year cures by radium, x-ray therapy and surgery consequently are compared with difficulty.

II. Illyés (Budapest, Reporter for Hungary) analyzed and discussed 1,262 cases of suppurations of the kidney, 1,079 of which came to operation. He classified his patients into three groups:

- I. Those with suppurative nephritis (46 cases were discussed).
- II. Those with suppurative pyelonephritis (455 cases were discussed).
- III. Those with pyonephrosis and renal atrophy (713 cases were discussed).

Two hundred and seven cases (16 operated on) of pyelitis of pregnancy were listed and discussed separately.

In the 41 patients who had unilateraliliary abscesses of the kidney, infection of the blood stream arose in the tonsils in 13, from pelvic infections following abortion in 8, from furuncles in 8, from an abscess following a gunshot wound in one, following pneumonia in one, from appendicitis in 6, and following an abscess of the prostate in one. Three cases were regarded as being lymphogenous in origin (diarrhea prominent before the onset). In 32 of the patients, the kidney was decapsulated and in 6, removed (type of treatment in 3, unstated). Of the 41, all recovered except 2, of whom one died of sepsis and one of myocardial disease.

Five cases of carbuncle of the kidney were discussed, all caused by staphylococcus infection. The reporter emphasized the danger of retrograde pyelography for diag-

*No mention is made of radical prostatic, urethral, vesicobulbostomy, after ureterointestinal implantation.

nosis in these cases because of the greater ease of pyelovenous and pyelo-interstitial backflow, producing septicemia. One of these patients died on the eighth day. In one case the carbuncle was opened and drained. There was a long convalescence with final healing. Nephrectomy was performed for the other three patients and all recovered.

In the group of patients with suppurative pyelonephritis (494), the infection was ascending in nature following urinary obstruction, of which hypertrophy of the prostate, tumors of the bladder, severe chronic forms of cystitis, and strictures of the urethra were the commonest causes. Suppurative pyelonephritis, however, occasionally followed simple catheterization of the ureter or pyelography. In the great majority of instances the organism was the colon bacillus. In a number of cases, unilateral suppurative pyelonephritis followed an obstructing stone in the ureter and in many cases followed renal stone, calculous pyelonephritis being included. Four hundred thirty-four of these patients were operated on. Sixty had bilateral involvement and were not operated upon. In 317 of those on whom surgery was performed, the suppuration was secondary to lithiasis either of the kidney or ureter, an incidence of 17 per cent in the personal cases (total 1,478 renal and ureteral stones). There were 175 nephrectomies for renal calculus and 28 cases of decapsulation after removal of the stone in the ureter. In the remaining 114 cases following obstructions in the lower tract, decapsulation was performed 46 times. In 117 patients, the cause of the pyelonephritis was unknown and in this group nephrectomy was performed in 92 and decapsulation in 25. Of the total patients with suppurative pyelonephritis, 10 died, giving a mortality of 4.3 per cent.

The third group comprised 713 cases of pyonephrosis, 590 of which came to operation; 181 patients were operated upon for primary pyonephrosis; for 174 of these, one-stage nephrectomy was done and, for 7, two-stage nephrectomy—that is, nephrotomy followed by nephrectomy. Ten per cent of the patients operated upon died. Among the 391 patients with secondary pyonephrosis (in 258 instances, secondary to calculus) there was an operative mortality of 8 per cent.

Four cases of atrophic pyelonephritis (pyelonephritischen Schrumpfniere) were mentioned, but the reviewer did not distinguish between atrophic pyelonephritis and fatty degeneration. One patient had renal atrophy with stone, another atrophy of an infected hydronephrosis, in another the condition followed infarction, and the fourth, a man sixty-three years old who had had his prostate removed six months previously, had a true atrophic pyelonephritis secondary to ascending infection.

Cabot (Rochester, Minnesota, Reporter for the United States) discussed in detail the first group cited in Illyés' classification, a group characterized by the infecting organism's being carried to the kidney in the blood stream from peripheral infections, particularly boils, carbuncles and septic wounds of the skin and acute infections of the upper respiratory tract. In a careful study of 46 patients with acute inflammatory processes about the mouth, throat, and ear, 32 showed organisms in the urinary smear, and 18 in culture, whereas, in a group of 10 apparently normal persons used as controls, the studies were negative throughout. The organism was a staphylococcus in most cases; as a rule, this can be recovered in the urine during the acute stage but may be absent later. The diagnostic importance of the limitation of movement of the diaphragm on the affected side and of the normal movements of the kidney, as demonstrated by fluoroscope or pyelography, was emphasized. Diminished visualization of the infected kidney in the excretory urogram has been noted. Four grades of this particular type of infection of the kidney by way of the blood stream may be distinguished clinically: (1) the fulminating group, relatively uncommon, which presents chiefly the complete overwhelming of the patient with a lesion apparently abdominal: pain, fever, rapid pulse, nausea, and abdominal distention are present. (2) The group of acute cases in which there are high fever, marked leucocytosis, and pain referred definitely to the region of the kidney with

local tenderness in the region of the kidney. The third, or subacute group, differs from the second only in the degree of the severity of symptoms and signs. In both of these groups a search of the urine for cocci in the early stages is usually successful. A fourth clinical group is composed of borderline cases in which the clinical picture is ill defined. Pathologically these clinical groups include the diffuse suppurative nephritides, the kidney with multiple cortical abscesses, the renal carbuncles, and perirenal abscesses. As indications for operation are given:

1. The fulminating type of infection.
2. The widespread infection of the kidney in which the patient seems unable to control the disease, as shown by the development of anemia and failing general condition.
3. Massive abscess of the kidney as shown by the pyelogram.
4. Perinephritic abscess.

Necker (Vienna, Reporter for Austria) recognized primary and secondary suppurations of the renal parenchyma without reference to the probable route of invasion. The primary suppurations are rarely diffuse but more often sharply circumscribed lesions of the cortex usually caused by staphylococci and only rarely by streptococci. Necker questioned the occurrence of primary suppurations in the cortex caused by *Bacillus coli*. Coecal lesions starting in the peripheral zones extend to form the clinical groups recognized as the rare diffuse cortical suppurations, the circumscribed miliary abscesses, the boillike carbuncles, the large intrarenal abscesses and the so-called xantholipomatous staphylomycoses. Secondary renal suppuration of the parenchyma usually arises from an infection with *Bacillus coli*. The progressive changes are often influenced in this group by dynamic factors of which pyelorenal backflow is one of the most important. The reviewer believes it is not possible at present to give a true clinical classification of the various types of cortical suppuration except possibly of the carbuncle.

III. Two of the reporters on the main subject, the physiology and pathology of renal excretion, confined their discussion mainly to hydromechanics. Pisani (Milan, Reporter for Italy) distinguished between the secreting and excreting functions of the kidney, the latter being mainly the transportation of the urine, after it has been formed, to the outside; it was this function of renal excretion which he discussed. He distinguished between excretory disturbances of motility, particularly with reference to peristalsis, disturbances of tone, and mixed disturbances in which alteration of both these dynamic factors plays a part. These various disturbances may be transitory or permanent and may arise from congenital malformations, from obstructive causes, whether congenital or acquired, from muscular or nerve lesions or any condition which disturbs the patency of the ureteral orifices. Dilatation of the excretory ducts represents the static element only and is often truly compensatory (hypotonic). Hypotonic-hyperkinetic dilatation may give good evacuation whereas hypotonic and nonkinetic dilatation means a permanent change with loss of function.

Rubritius (Vienna, Reporter in collaboration with Fuchs for Hungary) discussed excretion according to the laws of hydromechanics, emphasizing in particular the importance of reabsorption in relation to obstructions and the factor of minute tears in the fornices of minor calyces as balancing the amount of secretion with the amount of excretion. The amount formed in excess by the parenchyma of the kidney can be readily taken back into the circulation by this pyelovenous backflow.

Snapper (Amsterdam, Reporter for Holland) gave a masterly summary of the pathologic physiology of the secretion of the urine with a judicial discussion of the experimental evidence of glomerular and tubular activity, establishing the filtration-reabsorption-secretion theory. He also summarized the non-excretory functions of the kidney, in which he himself has done considerable work with respect to synthesis of hippuric acid and phenaceturic acid and of the oxidation and formation of an

monium in the kidney. Of interest is the final paragraph of his summary: "Urine is a supersaturated solution of many substances. Different substances, practically insoluble, are present in solution in the urine in large quantities. This problem is of great importance in the prevention of stone formation. The hydrotropic action of different organic constituents of the urine is discussed. Urea, hippuric, salicylic and mandelic acid and other substances often present in the urine, increase the solubility of calcium salts, especially of Ca oxalate. Besides this direct hydrotropic action, the stabilizing influence of these substances upon the colloids of the urine is of importance in the prevention of stone formation."

A REVIEW OF THE WISCONSIN CANCER INSTITUTE

ALEXANDER BRUNSCHWIG, M.D., CHICAGO, ILL.

(From the Department of Surgery and Division of Roentgenology of the Department of Medicine, University of Chicago)

Under the auspices of the Medical School of the University of Wisconsin and with the financial aid of the Wisconsin Alumni Research Foundation, a Cancer Institute in the form of lectures and round table discussions was held at Madison, Sept. 7, 8, and 9, 1936. On the last day, the meetings were held in conjunction with the State Medical Society. The address of welcome was delivered by President Glenn Frank who expressed his gratification that such a large number of workers in the field of cancer in the United States were present.

The following is a summary of the papers read:

The Influence of Extrinsic Factors in the Development of Induced Tumors in Animals. By Dr. L. Kreyberg, of the University of Oslo, Norway. In genetically controlled strains of mice, skin cancer was induced by tar painting and the effects of certain extrinsic factors on the development of the carcinomas observed. A diet high in magnesium seemed to delay the appearance of skin cancer. No effects were noted by high carbohydrate or fat diets. A liver diet appeared to hasten the development of benign warts but not the subsequent development of carcinomatous degeneration. In animals fed thyroid gland there was a higher incidence of tumors but their appearance was not hastened.

A second paper presented by the author was entitled **The Genetic and Constitutional Aspects of Spontaneous and Induced Tumors**. There is a genetic factor involved in the production of skin carcinomas by application of tar since in genetically pure strains the incidence and time of appearance of these tumors vary. A weak "irritant" in a mouse of strong constitutional susceptibility will produce carcinoma as will a strong "irritant" in an animal of little constitutional susceptibility. Spontaneous carcinoma of the breast in the mouse is in some way associated with ovarian activity since few males develop such tumors. Castration of the females at an early age reduces the incidence of spontaneous breast cancer. An association of breast cancer and ovarian tumors has been noted by the author in his colony of mice. There is no relationship between the susceptibility of a given strain of mice for tar tumors and the incidence of spontaneous mammary cancer.

The Influence of Intrinsic Factors in the Development of Tumors in Mice. By Dr. C. C. Little, Director of the Jackson Laboratory for Cancer Research, Bar Harbor, Maine. To the geneticist, the question of spontaneous tumor formation is a developmental phenomenon similar, perhaps, to the question of morphologic ab-

local tenderness in the region of the kidney. The third, or subacute group, differs from the second only in the degree of the severity of symptoms and signs. In both of these groups a search of the urine for cocci in the early stages is usually successful. A fourth clinical group is composed of borderline cases in which the clinical picture is ill defined. Pathologically these clinical groups include the diffuse suppurative nephritides, the kidney with multiple cortical abscesses, the renal carbuncles, and perirenal abscesses. As indications for operation are given:

1. The fulminating type of infection.
2. The widespread infection of the kidney in which the patient seems unable to control the disease, as shown by the development of anemia and failing general condition.
3. Massive abscess of the kidney as shown by the pyelogram.
4. Perinephritic abscess.

Necker (Vienna, Reporter for Austria) recognized primary and secondary suppurations of the renal parenchyma without reference to the probable route of invasion. The primary suppurations are rarely diffuse but more often sharply circumscribed lesions of the cortex usually caused by staphylococci and only rarely by streptococci. Necker questioned the occurrence of primary suppurations in the cortex caused by *Bacillus coli*. Coccal lesions starting in the peripheral zones extend to form the clinical groups recognized as the rare diffuse cortical suppurations, the circumscribed miliary abscesses, the boillike carbuncles, the large intrarenal abscesses and the so-called xantholipomatous staphylococcoses. Secondary renal suppuration of the parenchyma usually arises from an infection with *Bacillus coli*. The progressive changes are often influenced in this group by dynamic factors of which pyelorenal backflow is one of the most important. The reviewer believes it is not possible at present to give a true clinical classification of the various types of cortical suppuration except possibly of the carbuncle.

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dence from the physieist's point of view was presented to show why x-rays and gamma rays of different wave lengths should have different biologic actions. [The latter question, of great practical importance, is by no means settled.—A. B.]

The Reaction of Tissue Cells to Irradiation. By Professor Henri Coutard, of the Radium Institute, Paris, France. If 4,500 r. units of x-radiation measured on the skin are delivered in daily doses of 300 to 400 r. per day to the neck through two opposing lateral portals the epithelium of the mucosa of the fauceal regions, palate and pharynx, will be destroyed and the region become covered with a yellowish fibrinous membrane on the thirteenth or fourteenth day from the first exposure. On the twenty-eighth day the cutaneous epithelium will be destroyed and replaced by a similar membrane. Healing of these superficial irradiation "burns" is fairly rapid. If the daily dose is 200 r., milder epithelial reactions develop with peaks of intensity every thirteen to fourteen days. If 900 r. are delivered in daily doses to a total of 4,500 r. epithelial reactions do not occur since there is rapid massive necrosis of the underlying connective tissue.

The cardinal principle in the treatment of carcinoma by x-radiation is to deliver the optimal tumor dose (3,600-4,200 r. for nasopharyngeal tumors) in the proper chronology so that epithelial effects are maximum and connective tissue effects are minimum.

When the five-year "cure" statistics of 379 patients treated by the daily small dose method were reviewed, it was found that the majority of patients surviving were treated daily for periods of approximately 13 to 14 days, 23 to 26 days, and 38 to 42 days. It is thus suggested that the proper method of x-ray treatment may prove to be the delivery of large doses (2,400 to 3,000 r. surface measurements) in short series of 4 to 8 daily sittings at 13-day intervals for 2 or 3 series to a total surface dose of 6,000 to 8,000 r. Severe local tissue reactions are to be avoided even though this may mean reducing the dose.

[Coutard thus indicates departure from some of the principles previously enunciated by him and which have revolutionized x-ray therapy in the past few years.—A. B.]

Tissue Culture in the Study of Cancer. By Dr. Warren Lewis, Carnegie Institute, Washington, D. C. Moving pictures of normal and malignant cells in culture were exhibited. Aneboid and phagocytic activity, and mitoses were shown in a spectacular manner. Extensive observations indicate that the malignant cell is a permanently altered cell.

The Biology of the Cancer Cell. By Dr. S. P. Reimann, Professor of Experimental Pathology in the Graduate School of the University of Pennsylvania, Philadelphia. A review of experimental studies on the cancer cell. Malignant neoplasia may arise from excess number of cells, "spare parts," occurring in various organs as a result of aberrations in distribution of undifferentiated cells during the early development of the individual organ or tissues.

Filterable Viruses in Malignant Neoplasms. By Dr. J. B. Murphy, Director of Cancer Research, Rockefeller Institute of Medical Research, N. Y. That the filterable principle for the production of fowl sarcoma is actually a "living virus" has not been demonstrated. Its true nature remains unknown. A differentiation must be made between agents which actually induce malignant neoplasms and agents which maintain their growth and development. Tar injections may induce sarcomas in fowls, and from these tumors a filterable agent may be obtained which may induce similar tumors in other fowls. This principle is not present in the tissues before the development of tar sarcomas. In papillomas of rabbits induced by the Shope virus, a filterable principle cannot be obtained from the lesion when it becomes malignant.

normalities. It is not a simple Mendelian heredity because there is for breast cancer, for example, a close sex linkage, and there are linkages with other variable factors, all of which are not inherited. Further investigations are necessary for a clearer conception of the importance of the hereditary factors in the development of spontaneous tumors in these animals.

Familial Occurrence of Cancer. By Dr. Madge T. Macklin, University of Western Ontario, London, Canada. Under existing conditions of the population (in Canada) the laws of probability cannot account for the occurrence of the same types of cancer in related individuals (mother or father, and children). It must be concluded that in cancer in the human race an hereditary factor plays an important rôle. Knowledge of this fact on the part of the laity should lead to earlier medical consultation for symptoms referable to organs which in the individual family histories seem predisposed to malignant neoplasia.

Hormones and the Development of Atypical Growths and Malignant Tumors. By Edgar Allen, Professor of Anatomy, Yale University Medical School, New Haven, Conn. The follicular hormone is not only a powerful stimulant for the proliferation of certain genital epithelia and for the female and male breast, but is also a stimulant for the proliferation of certain mesoblastic tissue. The production of mammary cancer and of spindle cell sarcoma in mice by injections of large quantities of this hormone is of great importance in orienting further investigations of the mechanism of spontaneous malignant tumor formation.

Carcinogenic Substances in the Production of Tumors in Laboratory Animals. By Dr. H. B. Andervont, Biologist, U. S. Public Health Service, Boston, Mass. Some 40 compounds have been synthesized which are capable of inducing carcinoma when applied to the skin or injected into some of the parenchymatous organs, and capable of inducing sarcoma when injected subcutaneously. Among these are 1-2-5-6 dibenzanthracene, 1-2 benzpyrene and methyleholanthrene. Some of the carcinogenic compounds are feebly estrogenic. Isomers of some of them are less potent or innocuous. Simple "irritation" does not appear to be identified with carcinogenicity because some of the innocuous isomers are more irritating than the active compounds themselves. Although the anthracene nucleus is common to most of the substances, it is not indispensable for carcinogenicity. All of the compounds have at least two benzene rings. Methyleholanthrene, one of the most potent agents, may be derived from desoxycholic acid, a constituent of normal bile.

[The work of Kennaway, Hieger, Mayneord, Cook, Dodds, Barrows, and others on the synthesis of carcinogenic compounds constitutes the most important advance in experimental cancer research since the demonstration by Yamagiwa and Itchikawa in 1914, of the carcinogenicity of tar.—A. B.]

Public Lecture: Cancer, a Public Health Problem. By James Ewing, Memorial Hospital, N. Y. Attention was called to the increasing widespread interest in the study of all phases of the cancer problem. The usefulness of surgical treatment, which is becoming more limited in certain respects, is increasing as regards newer operations and in conjunction with irradiation therapy. The latter, from an insecure and minor position, has become a method of prime importance in the curative and palliative treatment of neoplastic disease. Specialization in the treatment of cancer should permit a more efficient clinical attack. There should be several heavily endowed cancer institutes in various parts of the country to lead in the development of more effective treatment and to serve as centers of research in cancer.

The Influence of Wave Length on the Biologic Action of Radiation. By Dr. Gioacchino Failla, Physicist, Memorial Hospital, N. Y. A review of the problems confronting the physicist in making ionization measurements of quantities of irradiation. An original method for such measurements was described. Evi-

REPORT OF THE THIRTY-SEVENTH ANNUAL MEETING
OF THE AMERICAN ROENTGEN RAY SOCIETY,
CLEVELAND, OHIO, SEPTEMBER 29 TO OCTOBER 2, 1936

LEO G. RIGLER, M.D., MINNEAPOLIS, MINN.

(From the Department of Radiology of the University of Minnesota)

THE annual meeting of the American Roentgen Ray Society held in Cleveland, Ohio, September 29 to October 2, 1936, consisted of a large number of papers together with an extensive scientific and technical exhibit. Only the more interesting contributions of this meeting will be reviewed here.

Doctors Howard Hunt, Russell Best, and Frederick Hicken, of Omaha, Nebraska, presented a paper on *The Radiographic Observation of the Biliary Ducts, During and Following Operation, by Cholangiography*. They reported that the biliary tract may be visualized by replacing 20 or 30 c.c. of bile with a nonirritating radiopaque material, such as hippuran, thorotrast or lipiodine by way of the gallbladder or biliary ducts. Immediate radiography at operation gives information regarding calculi in the ducts, strictures, neoplasms, fistulas, cholangiectasis and the patency or occlusion of the biliary ducts which may guide operative procedures. Post-operative visualization is done by injection of radiopaque materials through drainage tubes or external fistulas with demonstration of the above conditions and portrayal of the adequacy of operative and drainage procedures. This method, which has been used for several years, promises to be of great assistance in demonstrating the actual condition of the common duct both during and after operation. The development of a good technic for doing cholangiography in the operating room, as practiced by the authors, may make it possible frequently to avoid drainage of the common duct or to prevent secondary surgical procedures.

Doctors Haig H. Kasabach and Alexander B. Gutman, of New York City, presented a paper on *Osteoporosis Circumscripta of the Skull and Paget's Disease. Fifteen New Cases and a Review of the Literature*. They demonstrated quite clearly that osteoporosis circumscripta is a precursor of Paget's disease or, in a broad sense, an atypical form of Paget's disease. In 32 of the 47 cases which they collected from the literature, including their own cases, osteoporosis circumscripta of the skull was associated with typical Paget's disease somewhere else in the skeleton. In 5 cases in which osteoporosis circumscripta only was found, follow-up studies revealed the development of Paget's disease in or about the areas in the skull within two to eight years.

The classification, pathogenesis, pathology and roentgen features of *Acute Infections of the Mediastinum* were discussed by Dr. Coleman B. Rabin, of New York. He pointed out that the majority of suppurative lesions of the mediastinum arise from traumatic penetration of the cervical esophagus and cervical infections. The communication between a mediastinal abscess and its cervical origin may occasionally be demonstrated by injection of iodized oil. The clinical manifestations and surgical treatment of *Acute Infections of the Mediastinum* were presented by Dr. Harold Neuhoof, of New York. He reported a surprisingly high percentage of recoveries by means of surgical drainage. In the discussion, Dr. Claude Beck, of Cleveland, emphasized the point that many mediastinal infections

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The Effect of Bacterial Products on the Growth of Malignant Tumors. By Dr. H. B. Andervont, Biologist, U. S. Public Health Service, Boston. Filtrates of meningococci injected into or at a distance from a growing transplantable mouse sarcoma (sarcoma 180) induce an acute hemorrhagic exudate within the tumor which is followed by complete regression. *B. coli* filtrates (purified for the tumor necrosing principle) when injected into or away from growing transplantable mouse sarcoma 37 or sarcomas induced by 1-2-5-6 dibenzanthracene also induce this reaction within three or four hours. Carcinomas are not affected.

The Recognition and Treatment of Early Malignant Lesions of the Uterine Cervix. By Dr. E. Novak, Associate Gynecologist, Johns Hopkins Medical School, Baltimore. A discussion of the methods of early diagnosis of cancer of the cervix and uterus and of the radiologic and surgical treatment.

Treatment of Cancer of the Breast by X-Rays. By Dr. Henri Coutard. Experience has shown that some varieties of breast carcinoma are sufficiently radio-sensitive to be permanently controlled by x-ray therapy only. Further clinical investigation may lead to a means of differentiating those best treated primarily by x-radiation, regardless of size, and those best treated by radical operation with or without x-radiation.

On the evening of September 8, 1936, a public meeting was held in the Great Hall of the Memorial Union. An address broadcast by radio, was delivered by Dr. C. C. Little, Director of the American Society for the Control of Cancer, entitled "A Program for the Control and Prevention of Cancer." It was pointed out that cancer accounted for more deaths than any other single pathologic entity. While some forms of cancer are usually in advanced stages when only slight symptoms become manifest, a large percentage of patients with other types of malignant disease may be offered a good opportunity for cure if adequately treated in the early stages which are manifested (breast, uterus, buccopharyngeal cavity, etc.). A plea was made for a change of attitude on the part of the laity, not to regard cancer in secret horror but to face the issue openly. Whereas patients are usually proud to talk with their friends of what appears to them as spectacular recovery from a variety of diseases, the subject of cancer is rarely discussed. Patients who have been cured of cancer should not conceal this fact. The American College of Surgeons has records of over 25,000 cases of cancer controlled for five years or more. The American Society for the Control of Cancer is about to launch a campaign for publicity of cured cases and of the curability of certain of the more common forms when adequately treated in the early stages. This campaign will begin through cooperation with the American Federation of Women's Clubs, and is intended to reach all women in the United States. It is hoped that this will materially increase the number of early curable cases to seek medical advice, and to increase public interest and financial support for study of the disease.

The subjects of the several round table discussions were: Diagnostic Problems, Genetics in Cancer, Filterable Viruses and Cancer, Surgery and Irradiation in the Treatment of Cancer, Cytology of Malignant Neoplasms, and Etiology of Cancer.

The meetings were all well attended; the visitors were made to feel a hearty welcome. Many were permitted to meet personally men with whose writings only they had previously been familiar. The University of Wisconsin, and especially those immediately in charge of the Cancer Institute, are to be highly felicitated for the choice and conduct of the programs, and especially for the *idea* that such a gathering should take place. Now that Wisconsin has shown the way, it is to be hoped that other institutions will emulate the example. Only good can result from such an intimate and direct exchange of ideas and from such a personal contact of those working in the field of cancer.

and eosinophile adenomas are radiosensitive and probably can be controlled without surgery. The progress of the lesion can be accurately followed by visual field examination. Dr. Sosman pointed out that the basophile adenomas of the pituitary gland are rare as compared with the frequency of the chromophobe and eosinophile adenomas, but their effect upon the individual is much more marked. This tumor causes all of its bizarre and striking effects by hypersecretion and has no local or neighborhood pressure effects. It apparently produces systemic changes through the other endocrine glands. The basophile adenoma is quite sensitive to roentgen ray treatment as judged by the results in three cases which were reported in detail.

A new method of roentgen therapy which has been practiced in Germany since 1931 was described in a paper by Dr. Eugene P. Pendergrass, of Philadelphia, entitled *Roentgen Therapy by the Method of Chaoul*. Dr. Chaoul uses a very small, shockproof, fully protected x-ray tube which is brought into close contact with the lesion to be treated. It may be placed in the oral cavity, pharynx, vagina, or rectum if desired. Low voltage is used, and an effect similar to that of surface applications of radium is produced. It is being used in Germany as a substitute largely because of the inability of the Germans to purchase radium.

Doctors Ira I. Kaplan and Sidney Rubinfeld, of New York, presented a paper on *Prolonged Low Intensity Irradiation*. The authors devised a bedside x-ray therapy unit, constructed along shockproof lines, which would permit them to give, economically and safely, prolonged low intensity x-ray therapy treatments with the patient comfortably cared for in his own bed. The machine is operated at a relatively low voltage, 110 KV, with only 1 MA of current, and the filter employed is $\frac{1}{8}$ to $\frac{1}{4}$ mm. of copper plus 1 mm. of aluminum, treatment being given at a distance of 50 to 80 centimeters. The authors have treated a wide variety of cases in this manner; infectious processes, particularly, such as bronchiectasis, unresolved pneumonia, and psoriasis, were first attempted. Then leucemias and lymphogranulomas were added, and now the authors are studying the effects of this type of irradiation on malignant tumors. They have obtained some encouraging results in certain cases. By combining the principle of protracted fractional irradiation together with a modified continuous irradiation, they believe that they are presenting a new type of therapy which merits further study.

A paper on *Fracture of the Femoral Neck Following Irradiation*, by Doctors Harold W. Jacox, Robert G. Dalby, and Norman F. Miller, of Ann Arbor, detailed a series of 14 cases in whom spontaneous fracture of the femoral neck occurred following irradiation of the pelvis for gynecologic conditions. The exact cause was not apparent, but careful histologic studies in two cases revealed no evidence of metastasis.

Dr. Richard Dresser, of Boston, presented a paper on *The Production of Super Voltage Roentgen Rays by Means of the Van de Graaff Generator*. He described a method for the production of high voltage roentgen rays by a relatively simple apparatus. This consists of a high voltage body mounted on an insulator which is charged by means of electrons carried by belts running at high speed. An x-ray tube of the cascade type under continuous exhaustion is energized from this high voltage body, and small quantities of very high voltage x-rays may thus be produced.

Dr. Robert B. Taft, of Charleston, presented studies *Concerning the Radioactivity of Thorotrast by the Use of the Geiger Counter*. He found that 75 c.c. of the commercial preparation thorotrast gave a count equivalent to the gamma radiation of 1.37 micrograms of radium. This is in contrast with the failure to detect any radioactivity by the simple procedure of placing the thorotrast on an x-ray film.

are air-borne and that they are very common in animals; Dr. Alton Ochsner, of New Orleans, called attention to the value of bronchoscopic drainage in the treatment of mediastinal abscess.

A paper on Roentgen Kymographic Studies of Pulmonary Lesions, by Doctors Wendell Scott and Sherwood Moore, of St. Louis, dealt with the application of this relatively new method of roentgen study to the movements of the diaphragms, ribs, and mediastinum. By means of kymography the altered motion of these structures under various abnormal conditions such as bronchial stenosis from tumor or foreign body, chronic mediastinitis or pulmonary fibrosis can be graphically demonstrated. While the findings are essentially the same as those demonstrated by fluoroscopy, the kymogram permits a more accurate and permanent recording of motion. In surgical conditions of the thorax this method of study may prove of great value.

The Roentgenological Diagnosis of Pericardial Scars (Adhesive Pericarditis) and Encapsulated Pericardial Effusion was presented by Dr. Eugene Freedman, of Cleveland, and discussed by Dr. Claude Beck. Freedman described the roentgen findings in the cases which have been operated upon by Dr. Beck and indicated the general results of pericardiectomy (decompression of the heart) as practiced by Dr. Beck. Dr. Beck gave an outline of the indications for surgery in adhesive pericarditis and explained his objection to this term. He also discovered the fallacy of the Brauer operation in the treatment of this condition.

The Physiologic Consideration of Ileus was discussed by Dr. Alton Ochsner, who gave it as his opinion that the toxemia and loss of fluids are largely responsible for the fatal results of obstruction. He emphasized strongly the importance of intramural strangulation due to the great distention of the bowel. Ochsner is thoroughly convinced of the crucial value of the roentgenogram of the abdomen in the demonstration of ileus, but he believes that by this method alone adynamic ileus cannot be distinguished from mechanical obstruction.

A paper on Congenital or Infantile Dislocation of the Hips was given by Dr. Edward C. Vogt, of Boston. He presented evidence to indicate that the dislocation is not present at birth but occurs as a result of relaxation of tendons and ligaments in an otherwise normal joint. A Clinical and Roentgenological Study of Low Back Pain With Sciatic Radiation was presented by Drs. Carl E. Badgley and Fred Jenner Hodges, of Ann Arbor. They studied 500 cases and found little or no constancy in the roentgenologic findings in the lower spine in these patients. The most common change was a narrowing of the fifth lumbar intervertebral disc.

One of the striking contributions at this meeting was presented by Drs. Ambrey O. Hampton and J. Maurice Robinson, of Boston, on The Lipiodo-Diagnosis of Rupture of the Intervertebral Discs Into the Spinal Canal (With Particular Reference to Those Lesions Simulating Sciatica and Low Back Strain). They detailed the findings in 40 proved cases of clinically important intraspinal ruptures of the intervertebral discs. The majority of these patients were suffering with intractable pain simulating sacroiliac disease, sciatica, and low back strain. By the injection of iodized oil into the lumbar spinal canal, a characteristic defect in the shadow due to pressure of the displaced nucleus pulposus can be well demonstrated in the roentgenogram. The surgical relief by removal of this structure was reported.

A symposium on Adenomas of the Pituitary Body was presented by Drs. Elliott C. Cutler and Max T. Schnitker, W. W. Vaughan, and Merrill C. Sosman, of Boston. Clinical and roentgenologic findings in various types of pituitary tumors were described; the conclusion of both Drs. Cutler and Vaughan was that irradiation should be first attempted in tumors of the pituitary gland before resorting to surgery. It is their experience that about 80 per cent of the chromophobe

RÉSUMÉ OF THE MEETINGS OF THE ASSOCIATED
ANESTHETISTS' SOCIETIES AT THE FIFTEENTH
ANNUAL CONGRESS OF ANESTHETISTS,
PHILADELPHIA, OCTOBER 19 TO 23, 1936

EDWARD B. TUOHY, M.D., ROCHESTER, MINN.

(From the Mayo Clinic)

THIS past meeting was one of the largest assemblies of the Congress of Anesthetists. It was held in conjunction with the American College of Surgeons, and its representation included several renowned personages from the United States, Canada and abroad. The meeting was appropriately dedicated to the memory of the late Dr. E. I. McKesson.

The various scientific sessions dealt with practically all phases of anesthesia, emphasizing current research in anesthesia and analgesia and the newer methods of administering anesthetic agents. Interspersed among presentations at the general assemblies were various clinics at some of the local hospitals which dealt with the administration of anesthetic agents.

The University of Pennsylvania School of Medicine and Surgical Research had several demonstrations, under the direction of Dr. I. S. Ravdin and his associates. Both Dr. Ravdin and Dr. Goldschmidt gave presentations on the use of divinyl ether, and gave both clinical and experimental data relative to its usefulness as one of the new anesthetic agents. In brief, it was their opinion that divinyl ether should be used for operations which do not require more than an hour's time, and they emphasized the more conservative use of this agent for operations lasting up to a half hour. They have demonstrated experimentally that damage to the liver may result with too prolonged use or too rapid administration of divinyl ether.

Spinal anesthesia was discussed at some length by various investigators, as was also the use of several agents for producing it. Professor Trempe, of Quebec, advocated the use of nupercaine for spinal anesthesia, according to the method of Howard Jones, and this method and agent for producing spinal anesthesia were approved of by several other workers. There were numerous discussions, however, regarding the use of other types of agents, such as procaine, metycaine, and pantocaine. There is apparently no unanimity of opinion as to which agent or technic seems to be the most practical and valuable, since various agents in the hands of certain investigators seem to be satisfactory; and likewise, various modifications of spinal technic seem to be satisfactory in the hands of certain individual workers.

Epidural anesthesia was discussed by Dr. A. L. Soresi, of New York, and its usefulness as an added method of regional anesthesia commented on, especially for operations on patients who are more or less debilitated. Epidural anesthesia causes much less fall in blood pressure and is practically devoid of the complication of lumbar puncture headache. Undoubtedly epidural anesthesia will be used more and more frequently as the technic is mastered by more individuals. The secret of its use lies in the fact that the epidural space has a negative pressure, which can be measured by means of a simple manometer attached to the needle or by means of the so-called hanging drop technic of Dr. Soresi.

Cyclopropane anesthesia was quite thoroughly discussed by Dr. Harold Griffith, of Montreal, and by Dr. Eversole, of Boston. It was the current opinion that cyclo-

Two outstanding technical achievements were presented on the last day of the meeting. The first paper was entitled **Planigraphy and Tomography: The Roentgenographic Representation of Plane Sections of Solid Objects**, by Dr. Robert Andrews, of Cleveland. In this presentation there was shown, for the first time in this country, a new method of roentgenography with which many experiments have already been conducted abroad. The purpose of this procedure is to project images of predetermined plane sections of solid objects on a roentgen film, with sharpness, while the structures in a different plane of the same object are blurred and indistinct. This is accomplished by moving the roentgen ray tube in one direction while the film is moved simultaneously in the opposite direction during the exposure, the object remaining fixed. The tube and film move around a point which is fixed at the level of the desired plane. A simple example of this procedure is the roentgenography of the sphenoid sinus. By correct application of this principle, an anteroposterior projection of the skull may be obtained in which the sphenoid sinus stands out from its surroundings as a clear-cut sharp image, while the remaining structures of the skull are blurred and indistinct. The practical value of this innovation is still doubtful.

The second paper, **A Preliminary Report on Cine-Fluorography**, was one of the more important achievements of the meeting. This was presented by Drs. William H. Stewart, William J. Hoffman, and F. H. Ghiselin, of New York. By the use of a special lens, a very sensitive motion picture film, a highly sensitive fluoroscopic screen, and the application of heavy exposures, the authors have produced, for the first time, a very satisfactory motion picture made directly from the fluoroscopic image. The results were particularly good in the visualization of the thorax, although intraabdominal structures were also demonstrated. It is possible that the method will be of value chiefly for experimental research and teaching. At present the expense of the equipment and the excessive exposures make it impractical to use for diagnostic purposes. For study and teaching, particularly of diseases of the thorax, such motion picture films will no doubt be exceedingly useful.

RÉSUMÉ OF THE MEETING OF THE AMERICAN SOCIETY OF
ANESTHETISTS AT THE ACADEMY OF MEDICINE
NEW YORK, N. Y., OCTOBER 8, 1936

EDWARD B. TUOHY, M.D., ROCHESTER, MINN.
(From the Mayo Clinic)

DR. MILTON PETERSON, of Bellevue Hospital, presented a report on the technic for endobronchial anesthesia. The use of the direct laryngoscope* is essential, since the technic involves the passing of a curved rubber tube into the trachea and between the vocal cords, under direct vision. It is necessary that the patient be relaxed under surgical anesthesia before this maneuver is attempted; otherwise, unnecessary trauma to the region of the glottis may occur. The usual methods of induction are used, and nitrous oxide and ether vapor, or cyclopropane, are used as anesthetic agents. After the tube has been successfully directed into the trachea, it is advanced until resistance is felt, indicating that the tip of the endotracheal tube is at the bifurcation of the trachea. The direction in which the tip of the tube is rotated determines largely into which bronchus the endotracheal tube has entered. Usually, little resistance is encountered in passing the tube into either main bronchus. An inflatable rubber cuff of the Waters-Guedel type surrounds the endobronchial tube about an inch (2.5 cm.) from its distal end, so that, when intubation of the bronchus has been successfully carried out, a comparatively airtight circuit may be obtained by inflating the cuff. The cuff is inflated with air by means of a small syringe which is adapted to a small catheter attached to the large endobronchial tube. It was further suggested that the inflatable cuff would aid also in preventing secretions from the opposite bronchus from entering the lung to which the anesthetic is being administered. For the maintenance of anesthesia, the free end of the tube, as it emerges from the mouth, is connected by means of special adapters to the leads of a standard gas machine, and any of the usual anesthetic agents may be given through this endobronchial tube.

Dr. Van Gilluwe presented a motion picture of the carbon dioxide absorption technic and the use of cyclopropane for special surgical operations. He also described his method of intratracheal and endobronchial intubation by means of soft rubber tubing of the Magill type. In addition, he presented an ingenious demonstration which showed the passage of an intratracheal tube through an artificially constructed trachea and bronchial tree. Sections of rubber tubing of approximately the diameter and size of adult tracheal rings were joined together with transparent windows between the rubber rings, which permitted direct observation of the intratracheal tube as it was advanced into the trachea and main bronchi. The usual type of tube used for intratracheal or endobronchial anesthesia is made of soft rubber and possesses a natural curve so that it may be easily introduced, when greased with sterile petrolatum, through the nose and thence into the trachea. It may also be introduced orally under direct vision with a laryngoscope. The Magill intratracheal tubes are supplied in various sizes for children and adults. The average tube for an adult is approximately 26 cm. in length and 1.3 cm. in outside diameter. This particular size of tube will permit easy to-and-fro respira-

*A modified laryngobronchoscope, which permits direct vision in the region of the bifurcation of the trachea, is used by some workers. This instrument aids in passing the endobronchial tube into whichever main bronchus is to be used.

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propane is a very useful anesthetic agent, but that very definite care must be exercised in its administration, since it is a very potent agent, especially in its effect on respiratory and cardiac function.

The intratracheal method of anesthesia was presented in detail by Dr. Sykes and Dr. John Hunter and others, and they emphasized the point that it provides an adequate airway for to-and-fro respiration and furnishes improved surgical relaxation. Numerous new devices for introducing intratracheal tubes blindly through the mouth were shown, and also several other ingenious instruments for the administration of intratracheal anesthetics.

Intravenous anesthesia by means of some of the barbiturates was likewise discussed, and such agents as evipal soluble, pentothal sodium, and methynmal were submitted as useful agents in producing anesthesia of short duration by the intravenous route. The essential feature in the administration of barbiturates is that the agent must be administered very slowly and intermittently, and not according to body weight. The use of these agents should be limited to operations of short duration which do not require maximal muscular relaxation.

A report of 5,000 administrations of avertin for rectal anesthesia was made by Dr. L. B. Mueller, of Indianapolis. This is one of the largest series of cases in which avertin has been used, and it is quite striking on the basis of the large number of cases apparently without untoward results.

Dr. Brian Sword, of New Haven, presented a method of continuous gas and air analgesia for obstetric cases. The essential feature of this particular type of analgesia is that the patient is kept in a very mild state of anesthesia throughout the course of the first stage of labor. Technically the success of the method depends on having the aperture for the entrance of the anesthetic agent close to the patient's face and not near the intake for air at the top of the face mask. The advantage of this type of analgesia is that the patient can assist in labor, and at the same time the severity of the pains during labor are minimized. As labor progresses, the depth of anesthesia may be increased as is deemed necessary.

The use of cyclopropane in obstetric practice has proved quite satisfactory, and one worker stated that there was less uterine hemorrhage after the use of cyclopropane and less postoperative distention.

Several restorative or analeptic drugs were studied by Dr. E. A. Rovenstine, of New York, and in his opinion, coramine, pierotoxin, and metrazol were all suitable agents in the various types of cases studied. Any one of these particular drugs, if given in large enough quantities, will produce convulsions, but when given in therapeutic dosages they are stimulating in their action.

Complete papers covering these numerous phases of anesthesia will be published subsequently in the ensuing issues of *Current Researches in Anesthesia and Analgesia*, and anyone interested may secure the added information from that source.

Book Reviews

Recent Advances in Genitourinary Surgery. By H. Bailey and N. M. Matheson. Cloth. Pp. 205, with illustrations. Philadelphia and London, 1936, P. Blakiston's Son & Company.

This book better could be called "Current Practices in Urology," since it deals with many matters which are not, strictly speaking, recent advances. The reviewer assumes that it is intended to make available to the general practitioner and general surgeon the current trends in urology. Viewed in this light, it is a very valuable little volume, since it is concise, pointed, and contains a useful bibliography. Its value in this field would be much increased by the inclusion of critical comments from the authors. As it stands, it quotes in places conclusions of somewhat doubtful validity, particularly as concerns the proved value of certain recently developed operations, which certainly merit critical comment.

As a review of current literature for urologists, it is a little too brief to be compared with the "Yearbook of Urology."

The chapter on excretory urography is excellent, presenting clearly the indications, limitations, and value of the method. Particularly important is the emphasis upon its limitations in discovering small foci of tuberculosis, and upon the resultant indications for retrograde pyelography.

The view of the value of decapsulation in nephritis is unusually hopeful, and is one not generally held; many will question the notion that nephropexy is required whenever the renal pelvis sinks below the fourth lumbar vertebra.

The review of the present treatment of infections in the urinary tract is unusually complete, although the value of neosarsphenamine in chronic coccal infections is deserving of mention, and the ketogenic diet receives less space than it appears to deserve. The value of drainage by ureteral catheter or nephrostomy is emphasized.

The growing enthusiasm for conservative operations in hydronephrosis from obstruction at the ureteropelvic junction is reflected in this discussion. One would like to see the Schwyzer-Foley operation mentioned.

The section on urinary calculi contains an excellent presentation of current views of their etiology; the emphasis on the value of nephrostomy after the removal of renal stones is sound.

The newly developing operations upon the sympathetic innervation of the urinary tract are well discussed, although the views of the Harrieses as to the importance of disturbances of sympathetic innervation in causing renal pain are not yet widely accepted. Presacral neurectomy is explained.

The reviewer was a little startled to find, in a work entitled "Recent Advances," a discussion of the dangers of sudden emptying of the bladder together with a recommendation for recompression when the bladder is inadvertently emptied. This problem was mentioned in the Ebers Papyrus, and was frequently discussed at the beginning of the nineteenth century. The theory was revived at the beginning of this century, but its validity has never been proved. The persistence of this idea is regrettable, since it tends to cause the surgeon to blame nature for the disasters which often follow his introduction of bacteria into the distended bladder, and to delay acceptance of Bumpus' idea that it is the maintenance of rigid asepsis in catheterization, rather than the rate of emptying, which is important.

tion to occur within the tube, and will serve as a good airway in case artificial respiration is necessary. Intratracheal tubes and endobronchial tubes are also available with inflatable rubber cuffs at the distal end if so desired.

Dr. Sidney Wiggin, of Boston, considered the use of pontocaine (pontocain) and procaine in spinal anesthesia. In his experience, the administration of pontocaine alone has not given a complete sensory anesthesia in all cases, although motor paralysis was satisfactory. However, he has found that a combination of pontocaine and procaine has given satisfactory sensory anesthesia and adequate relaxation. In the 700 cases studied, in which pontocaine and procaine were administered as spinal anesthetics, he observed less nausea and less variation in blood pressure than when either procaine or pontocaine was used alone. Pontocaine is approximately ten times more potent than procaine and is noted for its prolonged action. The combination of about 60 per cent pontocaine and 40 per cent procaine has been a satisfactory mixture. For example, 6 mg. of pontocaine and 40 mg. of procaine would be the usual proportion for a dose of 100 mg. The patients to whom this mixture of spinal anesthetics was administered were carefully selected, and debilitated patients were omitted. As a means of determining the contraindication to spinal anesthesia in these studies, ephedrine sulphate was administered in doses of 50 mg. in order to ascertain the individual's response to the pressor agent. If 50 mg. of ephedrine sulphate did not raise blood pressure and improve the pulse of the individual under study within fifteen minutes, the spinal anesthetic was not used. The author routinely used the second and the third lumbar interspace as the site of injection and emphasized that the rate of injection of the anesthetic should not exceed 0.5 c.c. per second. He also has devised a special dilution table which he uses as a general guide in determining the doses and dilutions of the anesthetic for various types of operation. All of his patients received preliminary medication prior to spinal anesthesia, which generally consisted of $1\frac{1}{2}$ grain (0.097 gm.) of pentobarbital sodium, $\frac{1}{4}$ grain (0.016 gm.) of morphine sulphate, and $\frac{1}{150}$ grain (0.0004 gm.) of scopolamine. In a few cases, nitrous oxide and oxygen was used to supplement the spinal anesthesia. Postoperatively, unless there were contraindications, the patients were moved in bed from side to side frequently in order to prevent pulmonary disturbances. The usual intravenous and rectal methods were used for supplying fluids immediately after operation. Either a 5 per cent solution of dextrose or a physiologic saline solution was given. He concluded that the mixture of pontocaine and procaine was more satisfactory than either preparation used separately, from the standpoints of nausea, vomiting, respiratory depression, and variations in blood pressure.

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SURGERY

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Original Communications

THE TREATMENT OF CONGENITAL OPENINGS OF THE RECTUM INTO THE VAGINA—ATRESIA ANI VAGINALIS

VERNON C. DAVID, M.D., CHICAGO, ILL.

(From Rush Medical College)

CONGENITAL malformations of the rectum and anus differ widely, but in principle fall into rather definite groups. Trelat made a simple anatomic classification of four groups: (1) strictures; (2) imperforate rectum; (3) absence of the rectum; (4) abnormal fistulous communications. Bodenhammer made a very elaborate clinical classification, naming the numerous types. Atresia ani vaginalis falls into Trelat's anatomic group of abnormal fistulous communications, others of which are the cutaneous openings of the rectum into the perineum, scrotum, saelum, umbilicus, and the visceral openings of the rectum into the bladder, uterus, and urethra. These abnormal communications of the rectum are predicated on an embryologic failure of closure of the cloaca by the urogenital sinus which normally divides the cloaca into two separate parts, the anterior consisting of bladder, urethra, and vagina, and the posterior which is the rectum. This results in various abnormal openings of the rectum into the vagina, urethra, and more rarely the bladder. In 473 cases of malformations of the rectum and anus collected from the literature by Pennington, 167 were the result of persistence of the original opening of the rectum into the cloaca. There were 67 instances where the rectum opened into the vagina or vulva.

In 162 cases of these malformations occurring in the Boston Children's Hospital during a twenty-five year period, Ladd and Cross report 52 per cent having abnormal fistulous communications, and of these nearly half were rectal openings into the vagina or just outside the hymen.

There is an admirable summary of the status of the therapy of tumors of the bladder, and the authors' attitude toward transurethral resection of the prostate is unusually free from bias. Their conclusion that relatively large lateral lobes require prostatectomy will be disputed only by those of large experience with resection.

Many skeptics will be pleased by their reference to ureteral stricture as "this somewhat nebulous lesion." The more widely used methods of transplantation of the ureter into the bowel are described.

The chapter on the surgery of the adrenal quotes too many indications and omits to mention the very real danger of fatal postoperative adrenal insufficiency, a danger which will not disappear until it is possible to determine preoperatively whether both adrenals are present and functioning. The current work in the United States on adrenalectomy in hypertension is not mentioned.

The recent observations on the occurrence of the hormones of pregnancy in the urine in teratoma testis is well described, as is the injection treatment of hydrocele and varicocele.

There are also discussions of renal function tests, treatment of uremia, renal cysts and neoplasms, urogenital tuberculosis, retention and incontinence of urine, and sterility; but the data presented do not really belong to recent advances.

One may summarize by saying that here is a concise, excellent volume for the general practitioner or surgeon interested in keeping abreast of current practices, and lacking only a more critical attitude on the part of the authors.

Books Received

The receipt of books is acknowledged in this section and this statement must be regarded as sufficient acknowledgment of the courtesy of the sender. Selections will be made for more extensive review dictated by the interests of our readers and as space permits.

DISEASES OF THE CORONARY ARTERIES AND CARDIAC PAIN. By Robert L. Levy, Columbia University, New York. Cloth. Price \$6. New York, 1936, The Macmillan Company.

NEUROLOGICAL SURGERY. By Loyal Davis, Northwestern University Medical School, Chicago. Cloth. Price \$6. Pp. 429, with 172 engravings, 2 plates. Philadelphia, 1936, Lea & Febiger.

A TEXTBOOK OF SURGERY. By Frederick Christopher, Northwestern University Medical School, Chicago. Cloth. Price \$10. Pp. 1608 with 1349 illustrations. Philadelphia, 1936, W. B. Saunders Company.

MINOR SURGERY. By Frederick Christopher, Northwestern University Medical School, Chicago. Cloth. Price \$10. Third edition. Philadelphia, 1936, W. B. Saunders Company.

AMERICAN CHAMBER OF HORRORS. By Ruth DeForest Lamb. Cloth. Price \$2.50. Pp. 418. Second edition. New York, 1935, Farrar & Rinehart.

MODERN MOTHERHOOD. By Claude Edwin Heaton, New York University College of Medicine. With Introduction by Hazel Corbin. Cloth. Price \$2.00. Pp. 271. New York, 1935, Farrar & Rinehart.

been delivered three times, and neither her doctor, her husband, nor herself were aware of any abnormality until another doctor attempted to make a rectal examination. This strange episode also demonstrates that continence may exist with atresia ani vaginalis. As we have

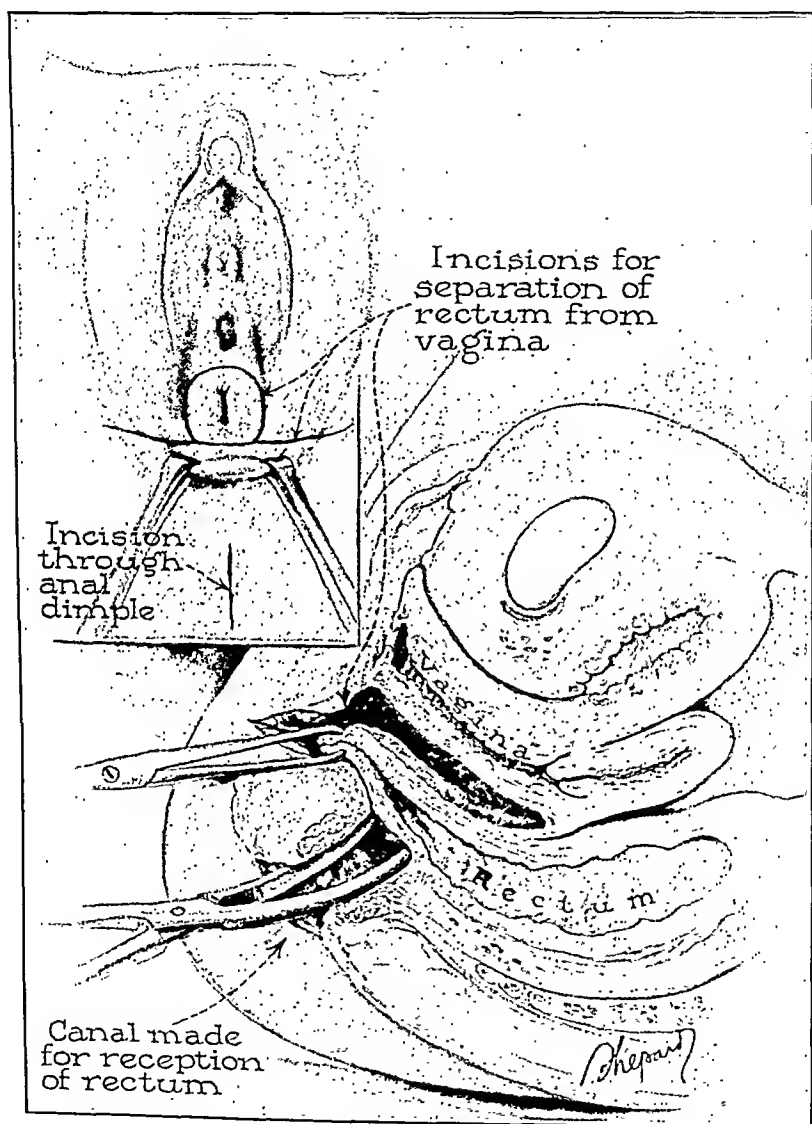


Fig. 4.—Operation carried out. Transverse incision surrounding vaginal opening of the bowel and a small longitudinal incision over the sphincter muscles. Wide mobilization of anterior wall of rectum is necessary.

delayed radical operation in our patients until they were six years of age, we have seen four of these patients develop normal control of the bowel action in its abnormal position, and in two of them there has been a definite separation of the rectal opening from the vagina

Our observations are based on the study and care of six children having the rectal opening inside the vulva just posterior to the hymen which was perfectly formed in all of the cases. In two of the children the vaginal opening of the bowel was small and insufficient so that symptoms of bowel obstruction were in evidence. It is important to think of the possibility of a vaginal opening of the rectum in infants

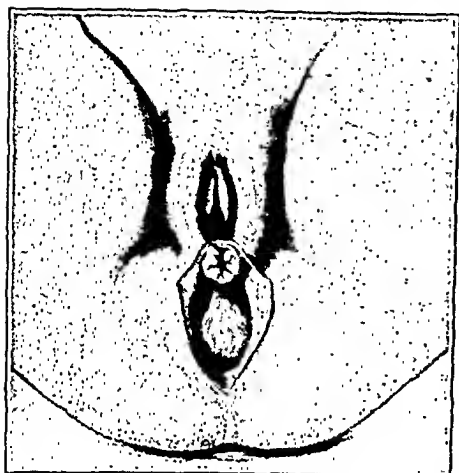


Fig. 1.

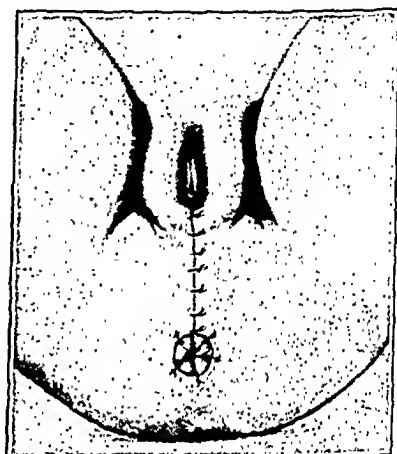


Fig. 2.

Fig. 1.—From second edition Ombredonne, "Chirurgie Infantile." Rizzoli operation—Raquet incision exposing the vaginal opening of the bowel as well as the proposed new site for the bowel opening.

Fig. 2.—From second edition Ombredonne, "Chirurgie Infantile." Rizzoli operation completed with bowel opening in normal position and operative defect closed.

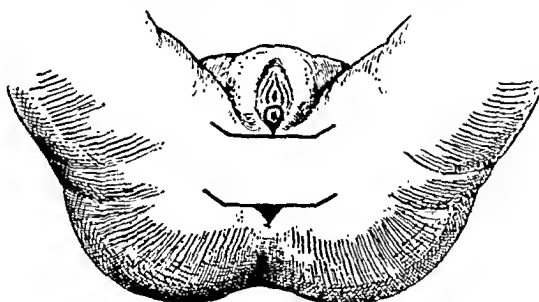


Fig. 3.—From second edition Ombredonne "Chirurgie Infantile." Incisions used for mobilizing vaginal opening of the bowel and for exposing the site of the new anal opening.

born without a normal anus, for the vaginal opening may be small and plugged with dried meconium so that acute obstruction develops. Four of the children had an ample bowel opening in the vagina so that normal movements began early and continued without any evidence of obstruction. In this connection many such patients have lived into adult life without knowing that any deformity existed. Delbet and Brechet quote Le Fort whose patient of forty-eight years of age had

are likely also to be absent. This has an important bearing on replacement of a continent vaginal rectum to its normal site where the opening would be largely incontinent.

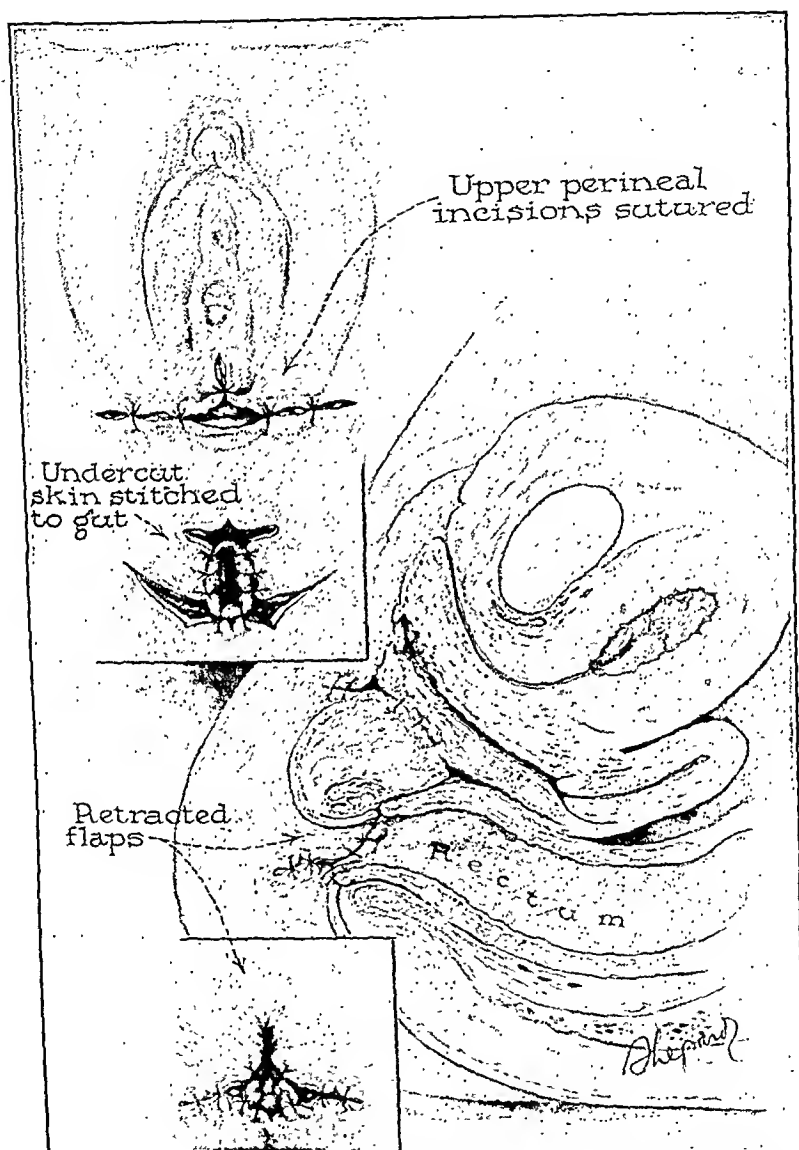


FIG. 6.—Skin flaps inverted into the anal opening and sutured to the end of the bowel. Vaginal defect closed.

Where the vaginal opening is small and insufficient and cannot be dilated and maintained at a proper size, a simple longitudinal division and transverse suture plastic of the rectal opening may be done as a temporary procedure. This was carried out in one infant who later

so that in one the rectal opening is now perineal and is sufficient and continent. It seems clear that operative interference in these four patients is not indicated, especially in view of the fact that in none

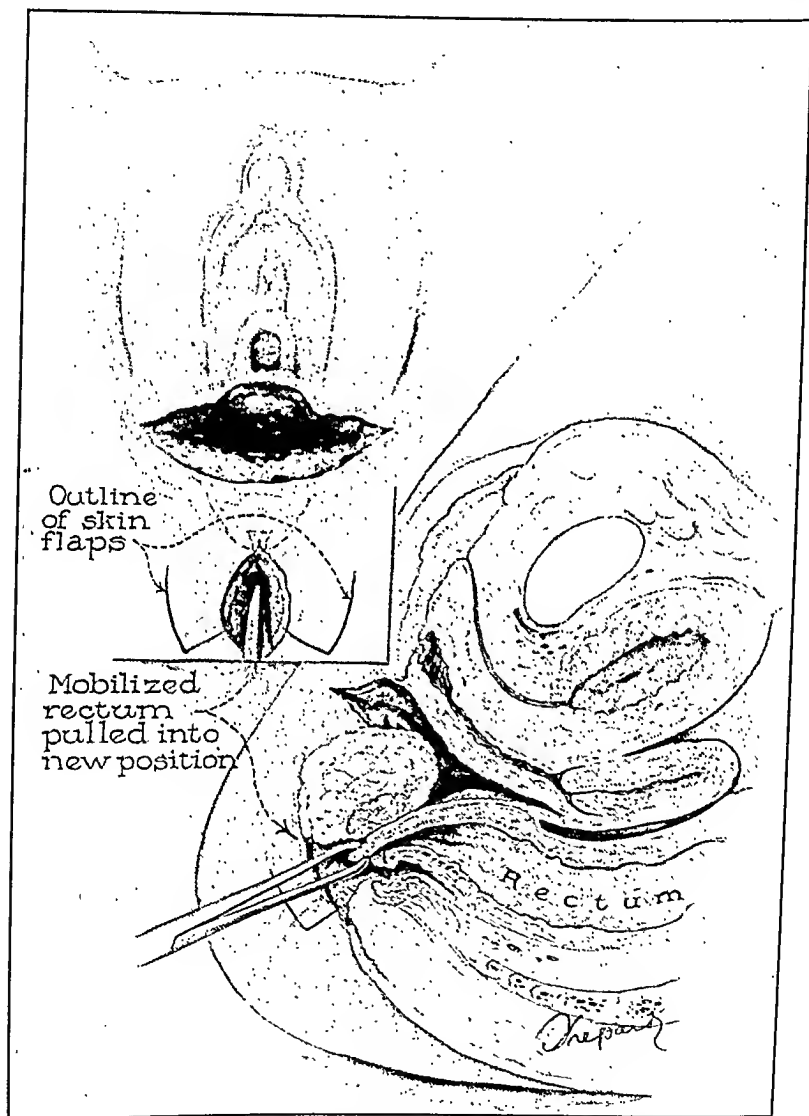


Fig. 5.—Shows formation of skin flaps at new anal opening which are inverted into the space occupied by the anus to be sutured to the terminal bowel.

of the four is there any evidence of the sphincter muscles at the usual anal site. It will be remembered that the sphincter muscles arise around the infolding of epithelium forming the proctoderm or anus. If the anal depression or puckering is absent, the sphincter muscles

FURTHER LABORATORY AND CLINICAL EXPERIENCES IN THE TREATMENT OF CHRONIC, UNDERMINING, BURROWING ULCERS WITH ZINC PEROXIDE

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SINCE the publication of our first reports on the favorable effect of zinc peroxide on anaerobic and microaerophilic infections,^{1, 2} we have had an opportunity of studying in some detail nineteen other cases which presented the typical picture of that devastating lesion of the skin and subcutaneous tissues which is caused by a microaerophilic hemolytic streptococcus and is called by the descriptive name "chronic undermining burrowing ulcer." Eight of these cases were seen in other hospitals and were cared for by other surgeons who have been kind enough to let me refer to them in this paper. Such references, however, shall be in general terms only, for these cases may be reported elsewhere by the physicians immediately responsible for them. The present paper is submitted in order to outline in some detail ten new cases of this rare disease (one more is now being treated), which have been cared for at the Presbyterian Hospital, New York City. Some of these cases had certain features which were not associated with the earlier cases, and we have had certain difficulties in the use of the zinc peroxide itself which were not encountered before.

The favorable action of zinc peroxide in the last three cases of the original series¹ was so striking that we fully expected similar results with subsequent patients. There were certain physical properties of the zinc peroxide, however, which seemed to be unfavorable, and we suggested to the manufacturers that an attempt should be made to alter these. The most important of these physical properties were the rapid sedimentation of the material when suspended in distilled water, and the retention of the material in the deep sinuses, owing to its drying or caking propensities. At first we attempted to obviate this by using a suspending medium which would evenly emulsify the material, but it was found that the oils and greases considerably diminished the bactericidal action of the peroxide. Gelatin proved to be a favorable suspending medium, but it had the disadvantage of being a good culture medium for organisms not affected by the zinc peroxide. The mann-

developed continence and some tendency of separation of the rectum from the vagina. Radical operative replacement of the rectum has not been carried out in this child, who is now seven years of age.

In patients whose vaginal rectal opening is incontinent, radical operative replacement of the rectal opening to its normal site should be attempted. The results are naturally much more satisfactory if the sphincter muscles are present at the site of transplantation.

In a field where no single surgeon's experience has been large, it may be interesting to briefly consider what surgical procedures have been done. Rizzoli, Pierre, Delbet, and Kirmisson have all used a raquet incision surrounding the bowel opening and continuing backward in the midline to the cœcex (Figs. 1 and 2). After separating the bowel from the vagina, the rectum was sewed to the skin in its new position, and the vaginal defect closed. Ombredonne has pointed out the tendency for the newly implanted bowel to retract, so that little by little it tends to assume its original position. Consequently he advocated the useful principle of transverse incisions at the site of the opening of the bowel and its intended site of transplantation (Fig. 3). Harvey Stone has recently reported three successful results using these principles, and we now record two and add what in our hands was a useful step in the operation. Recognizing the great tendency for the anterior wall of the transplanted bowel to retract, and also having had experience with the very annoying mucous discharge when the mucosa of the bowel was sutured to the skin, we have fashioned skin flaps (Figs. 4, 5, and 6), the free ends of which are sutured to the mucosa of the transplanted bowel. When the anterior wall of the bowel retracts, it pulls with it the skin, and thereby lines the anal orifice with skin. If additional skin is necessary to line the anal canal, this may be done at another sitting, forming the base of the flaps posteriorly. Using this principle on both of our operative cases, our patients have not only gained complete control by normal sphincter action, but have an anus lined with skin which affords considerable comfort to them by avoidance of a constant mucous discharge.

by undermining and burrowing rather than ulceration. This occurred in the region of the anus and perineum. It is possible that the toughness of the skin accounted for the nature of the process. The other case presented multiple lesions probably due to autoinoculation. Both areas responded favorably to the close application of zinc peroxide, but one required more extensive operative procedures than the original cases had received; in these cases healing was unaccountably delayed and the favorable change in the organism from hemolytic to green did not take place with the expected rapidity. Furthermore, cases under the care of Carl Burdick, of the Hospital for the Ruptured and Crippled; Fenwick Beekman, at Bellevue Hospital; John Garlock, at Mount Sinai Hospital; Herman Wuerthele, in Pittsburgh, Harry D. Sommenschein, of the Hospital of Bone and Joint Diseases; James P. Grier, of Evanston, Illinois; and M. J. Henry, of Louisville, Kentucky, behaved in the same way. All of these physicians reported favorable initial improvement following the use of zinc peroxide, with subsequent spread of infection on the continuation of its use. Burdick's patient responded at once to the application of zinc peroxide, but there was one setback lasting several weeks due to an overlooked extension; nevertheless, the wound finally healed in two months. The other patients improved steadily but not with the expected alacrity. Finally, I had an opportunity of visiting those in Evanston and Pittsburgh. It seemed, at the time, as if the zinc peroxide were not being effectively applied to all parts of the wound, and in both instances an operation seemed to be indicated to expose the deep sinuses. These operations were performed and the method of treatment which we had advocated was subsequently carried out by both of the physicians in charge of the cases. Although the patients showed considerable improvement for a short time, they did not do well. Further extension occurred, in one case during continuous treatment with zinc peroxide, and in the other case when the zinc peroxide had been discontinued for a period of three weeks following a skin graft. When activity recurred, both patients decided to come to New York (Cases 6 and 7). About the same time Henry, who had had variable results with zinc peroxide, decided to send his patient to us (Case 5). At the same time a fourth patient was referred independently, who had not been treated at all with zinc peroxide (Case 4). We therefore had an opportunity of studying four cases at the same time, and as we know now, due to the fact that we had a considerable quantity of the old peroxide left, they immediately responded to the treatment. The material which the other surgeons had been using was tested and found to be ineffective. These experiences of ours, coupled with the experiences of other physicians in various parts of the country, seemed to prove that ineffective preparations of zinc peroxide were being distributed. Some

facturers suggested the use of a 5 per cent pyrophosphate solution properly neutralized with dilute sulphuric acid. This acted as a fairly good suspending medium, but it frequently caused a burning sensation in the wound and occasionally irritated the skin. In order to obviate these difficulties the manufacturers finally decided to change entirely the method of preparing the zinc peroxide. By the new method they obtained a fine white powder which stayed suspended in water, and this seemed to obviate the necessity for using an emulsifying agent.

Just at that time another patient (Case 1) came under our care. The bones of the pelvis were involved in the process and although it was possible gradually to eradicate the disease from the soft parts, the infection spread in the bone, and we ultimately lost the case by the gradual development of amyloid changes in the viscera and the spread of an underlying tuberculosis in the lung. It was noted, however, that although the process in the soft parts improved and eventually healed, the organism did not undergo the characteristic change from hemolytic to green which was seen in the previous cases, and it was felt that at times the zinc peroxide had very little effect; that is, there was a retrogression in healing in the face of what appeared to be an adequate application of the drug. We suspected that the material made by the new process might not be as potent as the original material, but we were assured by the manufacturers that the chemical analysis showed that the new preparation had a somewhat higher percentage of zinc peroxide than the old. We were assured also that the material was very stable and that sterilization did not materially diminish the available oxygen. Our studies in the laboratory, however, seemed to indicate that the new material was not as effective *in vitro* against the organism as the old material had been, and reports began to come to us, from other surgeons to whom the use of zinc peroxide had been recommended, that different batches of zinc peroxide behaved differently. Some of them seemed to be effective while others seemed to be completely inert. This was particularly demonstrated in the case of chronic undermining ulcer of the axilla of a year's duration which was under the care of W. J. Merle Scott, of Rochester, who will report the case independently in some detail. Suffice it to say, the first material which he received and used resulted in a very striking clinical improvement in the lesion. The lesion responded within a day or two after the application of zinc peroxide, but when a second batch of material was obtained from the manufacturers, the process of healing promptly stopped, the infection began to spread again, and this spread did not stop until another effective material was obtained from the factory and applied.

During this period of uncertainty we had the opportunity of treating two more cases (Cases 2 and 3), the first of which was characterized

tainly would have done if we had been able to continue with the old zinc peroxide. Healing proceeded again slowly but steadily in the three surviving patients. After a short time another batch of the material was sent for trial. We were told that it was prepared in exactly the same manner as the effective material we were then using. We decided to put this to a clinical test by using it on one-half of the wound in Patient No. 6. We soon found that this material did not behave at all like the preceding batch. It hardened and made a plaster-like cast in the wound which moved with each respiration. This caused a superficial erosion of the new epithelium and produced bleeding from the granulation tissue. After three days' treatment it was obvious that this half of the wound was definitely worse, and this retrogression of healing proceeded for a period of about ten days, even after we had returned to the effective material. There seemed to be an inertia of motion which it was difficult to stop. After a period of ten days' reapplication of the effective material, which was continuing its good work in the other two patients, the third patient's wound began to heal again. From that time on, the three remaining cases made steady and uninterrupted progress toward recovery.

The DuPont Chemical Company could not explain why the second batch had this striking characteristic of hardening. We set about, therefore, to study more carefully in the laboratory some of the physical properties of the material. When we suspended the effective and ineffective batches in distilled water, a striking difference in the manner of sedimentation was at once apparent. The effective material sedimented promptly, leaving a clear supernatant fluid, while the ineffective material settled more slowly and left a milky supernatant fluid. In the course of an hour bubbles began to appear in the effective material, while none formed in the ineffective material. After standing for twenty-four hours, the sediment of the effective material became flocculent and curdy and contained numerous gas bubbles, whereas the ineffective material not only remained sedimented but became hard and formed a mould of the bottom of the tube. When these suspensions were set up in tubes which permitted the measurement of the gas, it was found that the effective material produced ten times as much gas as the ineffective in the course of twenty-four hours. An analysis of the gas indicated that at least 95 per cent of it was oxygen. These findings seemed to indicate that the rapid mobility of oxygen might be correlated with the effectiveness of clinical application. But still we could not be sure that the same rapid evolution of gas would take place under the conditions present in the wound. We found that when the zinc peroxide was suspended in broth, the evolution of the gas was markedly decreased, while it was very active in the presence of saline or ascitic fluid or gelatin. The bactericidal action, however, did

of these were sent to us to test for potency, and we found almost all of them ineffective. Furthermore, we sent a questionnaire to all of the physicians who had recently received zinc peroxide from the DuPont Chemical Company. Many of these replied that they were not favorably impressed. We finally persuaded the manufacturers that their new method was not producing effective material and urged them to return to the old process. By this time our supply of old material was almost exhausted, and we found it necessary to ask them to make hastily a new batch by the old process. This material was yellow, coarse, and sandy. However, because our supply of the old material was completely exhausted, we had to use the new material on the four patients under treatment. Within two or three days it was evident that the material was not effective. All of the patients showed an increased activity of the infection, with an increase of purulent exudation and a grayish change in the color of the granulation tissue. The new epithelium which had grown in from the margin, as well as the skin grafts which had become fused, began to melt away.

Case 4 showed a deep invasion in the region of the femoral vein which later went on to a suppurative thrombophlebitis, septicemia and metastases, and finally pulmonary embolism and death.

In Case 5, the wound was almost healed and the patient had been promised a discharge from the hospital within a few days, when suddenly a small spot of activity appeared in the middle of the grafted area.

In Case 6, the process, which seemed to have been halted at the ensiform cartilage, burrowed beneath this cartilage over to the opposite side and produced an extensive pocket of pus around the fused cartilages of the sixth, seventh, eighth, and ninth ribs.

In Case 7, the patient suddenly developed erysipelas which spread rapidly from the groin down to the foot, and after treatment with ultraviolet light, which produced a burn, deep abscesses formed in the calf and in the external malleolar region above the ankle joint.

My amazement and discomfiture may well be imagined. We reported the catastrophe to the manufacturers and as soon as possible received from them another batch which was a finely divided white powder similar to the first effective material. They stated that it was the same material only more finely ground. This simple change in the physical state of the material seemed to make all the difference between an ineffective and an effective product. More damage had been done in a few days, however, than could be corrected in as many weeks or months. One patient was lost, one required an extensive operation, one required a number of minor operations, and the fourth patient had to remain in the hospital for two months longer than would have been necessary, if the healing process had continued uninterruptedly, as it almost cer-

produced by the microaerophilic hemolytic streptococcus. Over the lower part of the back and sacral region there was a huge ulcer with deeply undermined margins. In the right gluteal region the undermining extended down to the posterior surface of the thigh where the infection had broken out through the skin in many places, forming a "cribriform plate" of the skin of the posterior thigh almost to the knee, with numerous bridges between the openings, some of which were covered with epithelium on the deep, as well as on the superficial, surface. The subcutaneous fat and fascia had been dissolved away, leaving the muscles exposed. Laterally, the undermining extended under the skin into both groins where there were large ulcers just above Poupart's ligament, with subsidiary ulcers nearby and sinuses leading down into the pelvis. X-ray films showed an osteomyelitis of the sacrum, as well as extensive involvement of the ilia and both sacroiliac joints. Cultures revealed a hemolytic streptococcus growing much more profusely anaerobically than aerobically. The ulcerated surfaces were covered with a pale, gelatinous, granulation tissue. In the back new skin had grown down from the upper margin and had extended over a fairly large portion of the ulcerated surface. Since the child was very sick, a



Fig. 1.—(Case 1) Contamination of an abrasion, twenty-five months after onset of disease, showing the extensive undermining of the skin with cribriform openings on back of thigh and over sacrum.

radical procedure was out of the question. She was therefore treated conservatively, and an attempt was made to apply the zinc peroxide to all parts of the affected surface. The powder was suspended in 5 per cent sodium pyrophosphate solution as a thick cream, and the wound was flooded with this material. The wound was then packed with gauze soaked in this suspension and covered with vaseline gauze to prevent evaporation. She began to improve almost at once, but after a period of three weeks of conservative treatment it was obvious that there was not adequate contact with all parts of the wound surface. The undermined skin margins on the back and thigh were therefore excised, leaving a bridge of skin over the lower gluteal region and on each flank. A portion of the skin which was removed at this operation was chopped up into many fine pieces with a tissue chopper and spread over the surface of the wound. These pieces were held in place by a single layer of coarse-meshed gauze which was sealed to the margins with collodion. A considerable number of these "salt and pepper" grafts "took" and were the nuclei of numerous islands of new epithelium.

take place in broth, even though the evolution of oxygen seemed to be minimal. At this point, although we did not in any sense feel certain that we had found the explanation for the respective activity or inactivity of the various preparations of zinc peroxide, it seemed that we had found a laboratory test which might prognosticate the clinical effectiveness of the material.

At a conference with the DuPont representatives, we asked them to attempt to duplicate the effective preparation. They set about preparing a duplicate product, but the first batch was not successful. The second and the third batches were then prepared, and one of these proved to have the desired qualities, both with regard to laboratory tests and clinical activity.

In the meantime three other cases, having the typical clinical characteristics, and bacteriologic findings of the undermining burrowing ulcer, were referred to us. These were treated with material which we had found to be effective. The infection came under control and the ulcers healed, although there were certain factors in each case which delayed the healing in certain portions of the wound.

During the past year, the DuPont Company has made strenuous efforts to standardize this material. Hal Beans, professor of analytical chemistry, of Columbia University, and Hans Clarke, of the Biochemistry Department of the College of Physicians and Surgeons, have collaborated in this effort, but the physical chemistry has remained obscure. It seems to be a most difficult problem, but the latest reports indicate that its solution has been found, and that effective material will soon be available for all who need it. Our laboratory experiences with zinc peroxide will be reported in more detail at a later date.

OUTLINE OF INDIVIDUAL CASES

CASE 1.—L. L., aged seven years. Unit History No. 417788. Admitted to Babies Hospital June 11, 1934; died Dec. 30, 1934.

History.—Three years before admission this child sustained a fall, injuring her back and right hip. In the region of the right hip there was a large contusion but no radiographic evidence of fracture. Three months later a swelling developed behind the right hip, and an x-ray then indicated the development of a tuberculous process of the right hip joint. She was placed in a cast which, in the course of time, produced an abrasion of the skin of the right sacroiliac region where an ulcer developed, which gradually increased in size. This was thought to be a tuberculous ulcer, but biopsy failed to confirm it. It did not respond to treatment but continued to enlarge. Subcutaneous abscesses developed in the neighborhood, which were opened in various hospitals during the course of a year, but the wounds did not heal. She was finally taken home and for the last year had received very little medical attention. Eventually she was brought to the Babies Hospital in a condition which is most readily understood by a study of the photograph which was taken at that time (Fig. 1). The lesion showed the typical characteristics of a chronic undermining, burrowing ulcer

tissues of the thigh posterior to the great trochanter. This pocket was opened from without and at the same time an attempt was made to remove as much of the diseased bone as possible on each side of the sacroiliac joints. Although zinc peroxide was immediately applied to the freshly cut bone surfaces, the margin of the excision was evidently not sufficient to permit a control of the infection in the bone, for when granulations developed they had the same pale unhealthy appearance that had been present before.

In the meantime the tuberculous process in the lung continued to advance, and it was evident that we were not going to be able to control either the lesion in the bone or the tuberculous process in the lung. We continued to treat her, however, as best we could, and gradually the wound in the thigh closed as the epithelium grew in from the margins and outward from the grafts. About this time the patient suddenly developed erysipelas, which started from the region of the back and extended all the way down the thigh and leg to the foot. This was controlled with ultra-



Fig. 4.—(Case 2) Contamination of a furuncle or a lymph gland with portal of entry not known. Two years after onset and four days after treatment with zinc peroxide had been begun. (Through a misunderstanding, admission photograph was not taken.) Note the burrowing up into the axilla and the small daughter ulcer above.

violet light and erysipelas serum, but the infection left her in a very debilitated condition. A week later she rapidly lost strength and died, six and one-half months after admission. Unfortunately, postmortem examination was denied by the parents. Figs. 2 and 3 show the progress of wound healing.

CASE 2.—P. D. Unit History No. 438170. Admitted Dec. 8, 1934; discharged April 27, 1935.

History.—A negro, thirty-one years old, was referred from the Southampton Hospital to the Dermatological Clinic and was admitted to the Medical Department of the Presbyterian Hospital under the care of the Dermatological Service, with the following history:

Two years before admission he had developed an abscess in the left axilla which slowly broke down and was opened by his local physician. It failed to heal, con-

Following this operation it was possible to get very much better contact of the infected surfaces with the zinc peroxide; granulations took on a healthy red color, and new epithelium grew on the margins as well as from the skin grafts. In the region of the sacroiliac joints, however, the granulations maintained their pale unhealthy appearance, and in these regions the exudation continued to be profuse.



Fig. 2.—(Case 1) After partial excision of the undermined skin flaps; the muscles are exposed, covered only by granulation tissue. The buttock skin was also undermined and had to be incised later.



Fig. 3.—(Case 1) Five months after admission. The skin on the thigh had almost completely healed, but the infection persisted in the sacroiliac joints and the contiguous bones.

Gradually the wounds in the thigh healed, but the infection burrowed down in the region of the anus and resulted in a perforation of the rectum and a contamination of that portion of the field with fecal material. An x-ray study of the pelvis following an injection of zinc peroxide into the sinuses leading down from the groins, showed an extension of the process out through the right sacrospinous notch into the

tinued to discharge, and during the course of six months it was lanced several times. At the end of that time an ulcer began to form, with undermined edges extending down the arm and over the chest wall, and with sinuses leading up into the axilla. This slowly increased in size and a year after the onset a similar lesion began to develop around the anus, which, however, was characterized more by burrowing and sinus infection than by extensive ulceration. But the lesion spread up in the gluteal fold and forward on each side of the serotum, then upward into each groin, toward the pelvis. Both lesions had steadily increased in extent and had responded to no form of general or local treatment. He was treated on the Dermatological Service for eleven weeks. Biopsies had failed to reveal any tuberculosis, actinomycosis, or other fungi. The Wassermann test was negative; the blood sugar was normal; a

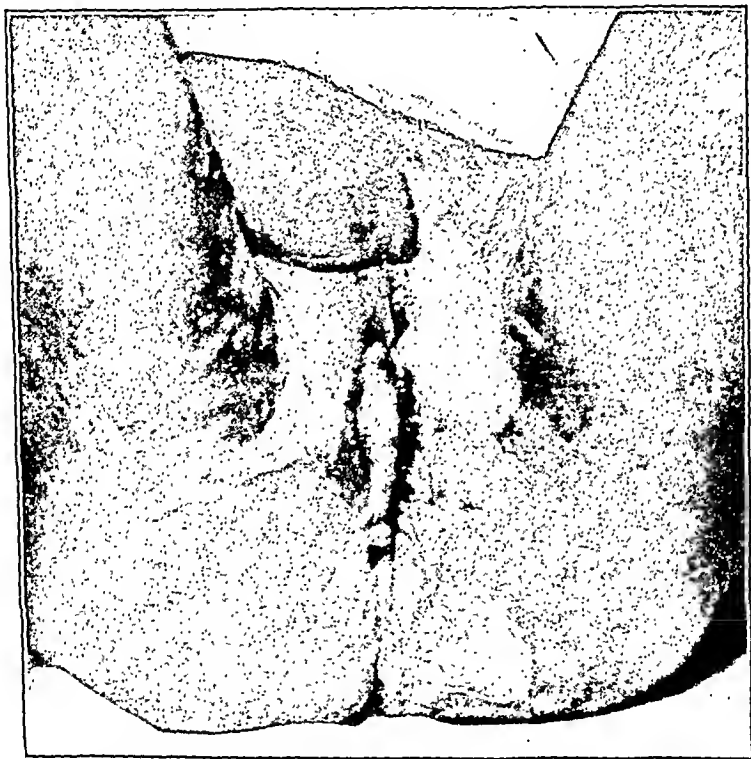


Fig. 7.—(Case 2) Three weeks after excision and zinc peroxide treatment. Wounds are clean and new epithelium has grown in from the margins.

blood count showed anemia and leucocytosis. Aerobic cultures revealed only *Staphylococcus albus*. A specimen of tissue was injected into a guinea pig which was killed six weeks later without any evidence of disease. The Frei test for lymphogranuloma inguinale was twice negative. A series of x-ray treatments caused no improvement. Nonspecific protein was injected without success. Smears showed no amebas. Azochloramide had no effect. He was finally given prolonged baths in potassium permanganate, without any improvement. He was then referred to the Surgical Service where his condition was recognized as that of chronic undermining ulcer due to the microaerophilic hemolytic streptococcus. This organism was found in anaerobic cultures along with several other organisms, namely, hemolytic *Staphylococcus aureus*, *Staphylococcus albus*, *Streptococcus viridans*, and *Bacillus proteus*. Because of the

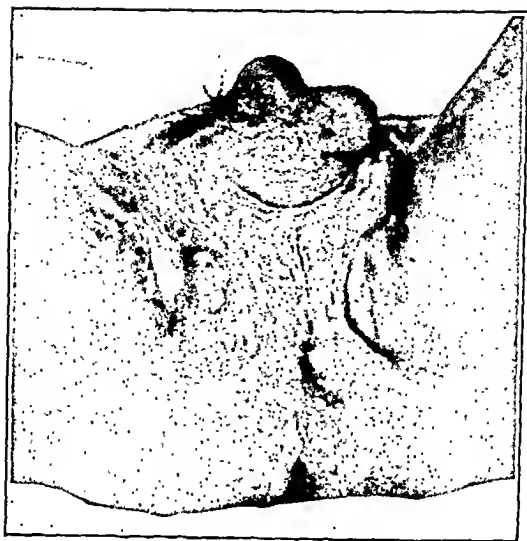


Fig. 5.—(Case 2) Autoinoculation. On admission, one year after onset of lesion and two years after axillary involvement. Extensive burrowing and sinus formation rather than extensive ulceration were the outstanding features of this lesion.



Fig. 6.—(Case 2) Three weeks after zinc peroxide treatment was instituted, axillary burrowing had filled in and new epithelium had covered most of the ulcer.

bandaged it. It very soon became red, sore, and swollen. After a few days it was opened further and found to be discharging a seropurulent exudate. It failed to heal and six weeks later it was incised again and packed with iodoform gauze. The infection, however, continued to spread, and two months later a third operation was performed. Cultures revealed hemolytic streptococci and other organisms. About a month before admission to the hospital he developed several similar small ulcers on the inner surface of the left thigh and on the outer surface of the left leg near the ankle, which steadily increased in size and did not respond to any form of treatment. On admission, the lesion appeared as shown in Figs. 10, 11 and 12. There was a dirty, irregular ulcer on the ulnar side of the right hand extending posteriorly to the dorsum, with a large area of undermining beneath rolled-in skin margins. This



Fig. 9.—(Case 2) One year after healing, scars soft and pliable, very little limitation of function.

undermining extended also on the palmar surface to a limited degree. The exudate had a very foul odor and cultures yielded not only hemolytic streptococcus, which grew very much more profusely anaerobically than aerobically, but also showed an anaerobic gram-negative bacillus. Cultures from the thigh wound yielded no growth aerobically but hemolytic streptococcus anaerobically. Cultures from the leg ulcer yielded *Staphylococcus albus* aerobically and hemolytic streptococcus anaerobically. It was obvious that we were dealing with a typical case of chronic undermining ulcer due to the microaerophilic streptococcus, and that the lesions on the thigh and leg were of the same nature, probably produced by autoinoculation. We decided to treat the case conservatively with zinc peroxide in the hope of obtaining satisfactory contact with all parts of the infected surface without radical operation. The wound

extent of the undermining the patient was treated radically, with excision of the sinus tracts and the overlying skin flaps. The wounds were dressed with a creamy suspension of zinc peroxide in distilled water, after which they were all packed open with fine-meshed gauze saturated with the zinc peroxide suspension and sealed with fine-meshed gauze impregnated with zinc ointment. Improvement was evident within a few days. Pink, firm granulations began to develop from the fresh surfaces and new skin grew in from the margins. In one or two places, however, where the skin tended to roll under, healing was delayed, and from time to time small portions



Fig. 8.—(Case 2) One year after healing, scars soft and pliable, very little limitation of function.

of overhanging or rolled-in skin had to be excised. Nevertheless, the healing process continued favorably and steadily, and the patient left the hospital nine weeks after the beginning of the zinc peroxide treatment (Figs. 4 to 9).

CASE 3.—M. L., aged fifteen years. Unit History No. 444371. Admitted Feb. 11, 1935, and Apr. 29, 1935; discharged Mar. 29, 1935, and May 14, 1935.

History.—Six months before admission this boy had punctured the ulnar border of his right hand with a window screen wire, which lodged there for a few hours before being removed by a local physician who dressed the punctured wound and

bandaged it. It very soon became red, sore, and swollen. After a few days it was opened further and found to be discharging a seropurulent exudate. It failed to heal and six weeks later it was incised again and packed with iodoform gauze. The infection, however, continued to spread, and two months later a third operation was performed. Cultures revealed hemolytic streptococci and other organisms. About a month before admission to the hospital he developed several similar small ulcers on the inner surface of the left thigh and on the outer surface of the left leg near the ankle, which steadily increased in size and did not respond to any form of treatment. On admission, the lesion appeared as shown in Figs. 10, 11 and 12. There was a dirty, irregular ulcer on the ulnar side of the right hand extending posteriorly to the dorsum, with a large area of undermining beneath rolled-in skin margins. This



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was therefore flushed with a creamy suspension of zinc peroxide, packed beneath the flaps with fine-meshed gauze soaked in zinc peroxide, and the whole dressing covered with fine-meshed gauze impregnated with zinc oxide ointment. The foul odor of the discharges disappeared at once, and the gram-negative anaerobic bacillus thereafter failed to grow, but the hemolytic streptococci did not undergo the expected change from hemolytic to green, and after a week of conservative treatment the undermined flaps were excised. This was done satisfactorily, it was thought, on the back of the hand, but we compromised to some degree on the palm in order to avoid extensive loss of tissue (Figs. 13 and 14). The wound was then treated as before with zinc peroxide. Following this treatment granulations appeared somewhat slower than we expected and, much to our disappointment, the hemolytic streptococci persisted in the culture. When, however, the granulations had grown so as to cover the wound,



Fig. 10.



Fig. 11.

Figs. 10 and 11.—(Case 3) Contamination of small puncture wound. On admission, six months after onset of disease, showing shaggy, gelatinous granulation tissue with undermined and rolled-in skin margins.

we attempted a Thiersch skin graft, but this was completely lost by the collection of pus beneath it. The organism was also found to be particularly resistant to the bactericidal action of zinc peroxide in the test tube, and we came to the conclusion that we were dealing either with an inferior preparation of zinc peroxide or with a particularly resistant organism. Although new skin began to grow in from the margins, it was not uniform, and in three places healing ceased and undermining began again. At the same time the lesions on the thigh and foot which had not been excised showed evidence of activity, with a graying of the granulation tissue and an undermining of the margins, although several of the smaller lesions healed under the zinc peroxide without excision, where apparently contact was more complete. It therefore seemed best to excise the lesion on the thigh and two of the ulcers on the leg. A little later the small areas of undermining at the margin of the hand wound were also



Fig. 12.—(Case 3) Lesions on leg. Autoinoculation. The undermining is not as extensive as in the primary lesion.



Fig. 13.



Fig. 14.

Figs. 13 and 14.—(Case 3) Undermined skin flaps excised—widely on dorsum, conservatively on palm.

excised, and one by one these came under control; but only after the most careful application of the zinc peroxide by means of small toothpick swabs and close contact of fine silk ribbon soaked in zinc peroxide. The groove on the palmar surface was

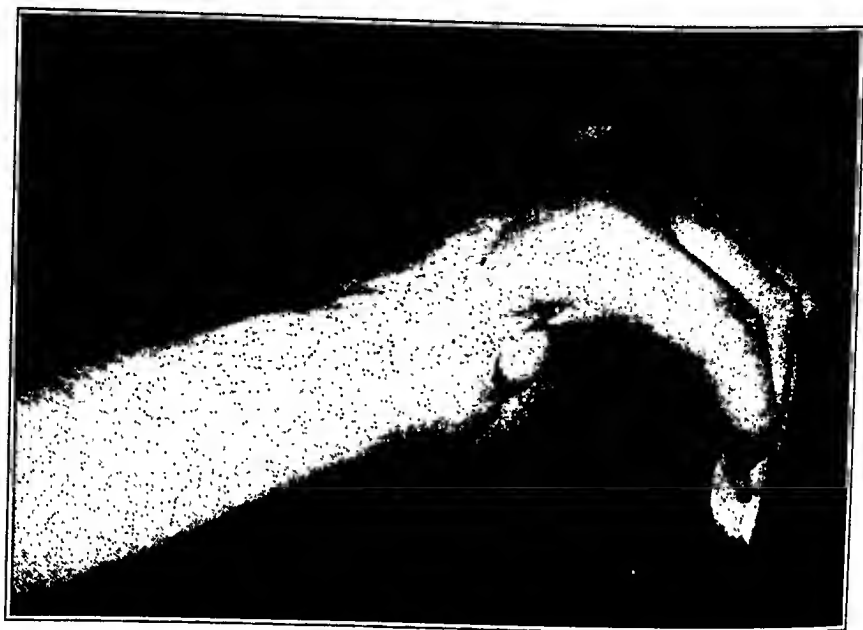


FIG. 15.

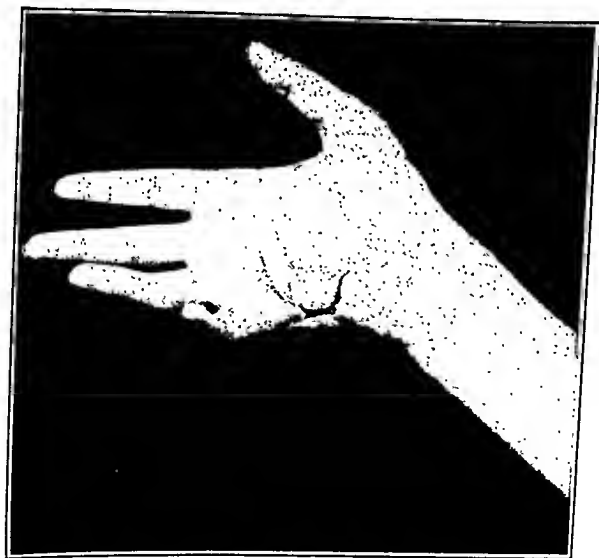


FIG. 16.

Figs. 15 and 16.—(Case 3) Final healing. Some flexion and adduction contracture but excellent function of the hand.

the last to heal, but finally the cultures became negative and thereafter the wound very promptly closed. The ulcer on the thigh closed satisfactorily after excision,

but one of the leg ulcers was very persistent and required a second excision before it finally yielded to treatment. Figs. 15, 16, and 17 illustrate the final state of healing.

CASE 4.—S. S., aged seventeen years. Unit History No. 454800. Admitted June 3, 1935; died Sept. 7, 1935.

History.—Nine months before admission this girl had scratched her right big toe on a board walk. It promptly became swollen and infected, but the process subsided completely in a few weeks. One month after the toe injury she felt a pain in her right groin, and a swelling appeared. This gradually increased in size and did not respond to local applications of heat, but slowly came to the surface and broke in several places. A physician then connected the sinus openings and it continued to drain. The lesion then spread slowly downward along the inner and anterior aspect of the thigh almost to the knee, and was not checked by repeated operative procedures during the next six months. She had not been confined to bed for any great period of time; but since she ran a moderate fever occasionally, she was confined to the house.

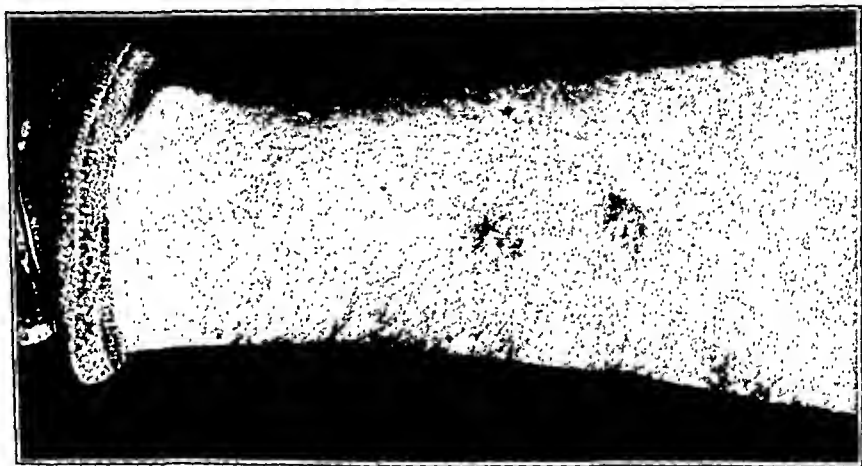


Fig. 17.—(Case 3) Final healing of the leg wound; minimal, flat, soft scars.

On admission to the Presbyterian Hospital the lesion appeared as illustrated in Fig. 18. Below Poupart's ligament there was a large pyriform ulcer with undermined margins extending downward over the anteromedial aspect of the thigh almost to the knee. There were numerous small daughter ulcers which had been produced, not by undermining from beneath but by inoculation from without. Because of her good general condition the lesion was treated conservatively. By that time we were well aware that the zinc peroxide made by the old method was effective and that made by the new method was ineffective. We therefore used only the old material. The wound was dressed with fine-meshed gauze soaked in a creamy suspension of zinc peroxide and sealed with fine-meshed gauze impregnated with zinc oxide ointment. Many of the small daughter ulcers cleared up at once; granulations took on an active red healthy appearance; the undermined margins in many places began to heal, and new skin began to grow in from adherent margins. It was obvious, however, after two weeks of conservative treatment, that there were pockets which were not being adequately reached. These were widely opened, and the lesion was treated radically (Fig. 19). When this operation was done, however, it was seen that the femoral lymph glands around the junction of the saphenous and femoral veins were the site

of deep involvement, so that a compromise was made here. The more superficial glands were removed, but several of the deep glands, which were not more than 3 or 4 mm. in size, were left. Following this procedure, healing progressed very satisfactorily except in the region of the femoral glands, where a swelling occurred in the remaining nodes and a small sinus persisted downward along the nodes to the region of the femoral vein. Also, undermining persisted under the skin of the ab-



Fig. 18.—(Case 4) Lymph gland type. On admission, nine months after onset of illness. Note the gelatinous granulation tissue in the groin ulcer with undermined, rolled-in skin margins. There are numerous daughter ulcers, probably produced by inoculation from without.

dominal wall, making it difficult to get adequate contact in this region. Skin grafts were applied, however, and took well over the lower two-thirds of the lesion, and the process seemed to be in a fair way toward healing (Fig. 20). Just at this stage, our supply of the effective material was exhausted and a new batch, hastily made, which was sandy, coarse, granular, and yellowish in color, was used—not only

on this patient but also on the three subsequent cases of this series, all of which were being treated at the same time. In two or three days it was apparent that the region of the femoral glands and femoral vein was taking on renewed activity. Granulations became pale, the sinus down beneath the glands enlarged, the exudate increased, and the skin beneath the groin became more deeply undermined. Within a week, effective material had been obtained, but the damage had been done. The glands had become greatly swollen, and it seemed necessary to attempt their removal. The patient was therefore subjected to an operation in which the femoral glands were



Fig. 19.—(Case 4) After six weeks of conservative treatment, the involved area was finally excised. Extensive burrowing was found, as well as involvement of the glands over the femoral vessels.

removed down to the deep fascia; but in doing so a branch of the femoral vein, possibly the stump of the saphenous which had previously been ligated, was opened, and there was a rush of venous blood from the depths of the wound which could not be controlled except by packing. Following this operation the patient had a high fever and developed a positive blood culture with the hemolytic streptococcus. Pneumonia supervened with an exudation of fluid into the pleura, a culture of which, however, was reported negative. The patient developed a pain in the first left metacarpophalangeal joint which we thought was certain to break down, but which gradu-

ally subsided. She did, however, develop a metastatic abscess in the outer surface of the right leg which had to be incised, and the organism was cultured from it. The temperature gradually came down and the positive blood culture disappeared, but purulent discharge from the depths of the wound steadily increased. A small catheter



Fig. 20.—(Case 4) Progressive healing of main ulcer. At this stage the supply of effective zinc peroxide became exhausted. Following the application of ineffective material a sinus formed, which extended up into the femoral vein.

passed into the sinus seemed to indicate that it was relatively short, but on the instillation of zinc peroxide the sinus suddenly accepted a fairly large quantity of the material. Very soon the patient said that she felt queer and went into a shaking

chill, with a temporary loss of consciousness. This, however, passed off promptly without a corresponding rise in temperature. Since we believed that a large cavity had been entered, an x-ray film was taken which showed the shadow of the zinc peroxide extending upward along the iliac vessels almost to the midline. It was thought that this represented a sinus tract along the vessels, and after considerable deliberation it was decided that the only hope of recovery lay in the effectual irrigation of this tract. The next day, therefore, zinc peroxide was again injected into the sinus, but this had no sooner been done than the patient promptly became uncon-



FIG. 21.—(Case 4) Autopsy specimen, showing the sinus from the upper part of the ulcer entering directly into the femoral and thence into the iliac vein.

scious and stopped breathing. The heart continued to beat for another ten minutes; but in spite of the very prompt application of the pulmomotor, the patient did not respond.

Autopsy showed that this tract, instead of being along the site of the vessels, was actually a suppurative phlebitis of the iliac vein (Fig. 21). The injection of zinc peroxide had blown off the upper end of the thrombus so that both the blood clot and the zinc peroxide embolized into the lung. It is not known, in this case, at just what time the suppurative iliac thrombophlebitis developed, but it is probable that it ap-

peared just before or just after the last operation, and it seems reasonable to believe that this occurred as a result of the application of ineffective zinc peroxide.

CASE 5.—C. S., aged twenty years. Unit History No. 456711. Admitted June 12, 1935; discharged October 21, 1935.

History.—Fourteen months before admission the patient had been operated upon for a recurrent appendicitis. The wound was closed without drainage, became infected, was opened, and continued to drain for several weeks. It then began to show undermining of the skin edges and gradually developed an extensive ulcer which steadily increased in size and spread over the right lower quadrant of the abdomen.



Fig. 22.—(Case 5) Infection of wound following abdominal operation (appendectomy). On admission, fourteen months after onset of illness. Note the gelatinous granulation tissue base, the widely undermined and rolled-in skin margins, the three small and one large daughter ulcers formed by erosion of the skin from beneath, and the bridge of skin.

It was treated with an infinite variety of antiseptics, both mild and drastic, including Harrington's solution, and partial excision was done on occasions; but the process continued in spite of all forms of local and general treatment.

After being ill for eleven months, the patient was sent to the Mayo Clinic where she was treated with local applications of antiseptics without effect. Tissues examined for tuberculosis were negative; blood Wassermann was negative even after the provocative salvarsan. Light treatments were used, cysteine was tried, both without effect. At that time Pemberton wrote to me concerning this

case; he described it and said he thought that it was similar to the ones presented in my previous report. On that basis he had used zinc peroxide, but although his patient showed improvement, the infection did not come under complete control. After two months in the Mayo Clinic, the patient returned home where she continued to receive conservative treatment with zinc peroxide; and

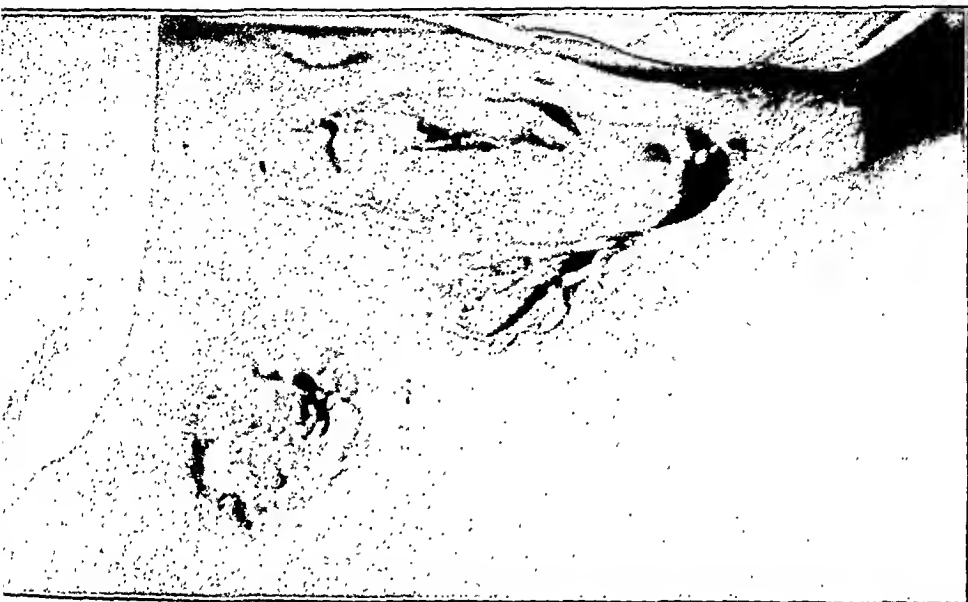


Fig. 23.—(Case 5) Lateral view of the lesion on admission. The skin between the main and lateral ulcers was undermined. Contact of the zinc peroxide without excision was obviously impossible.

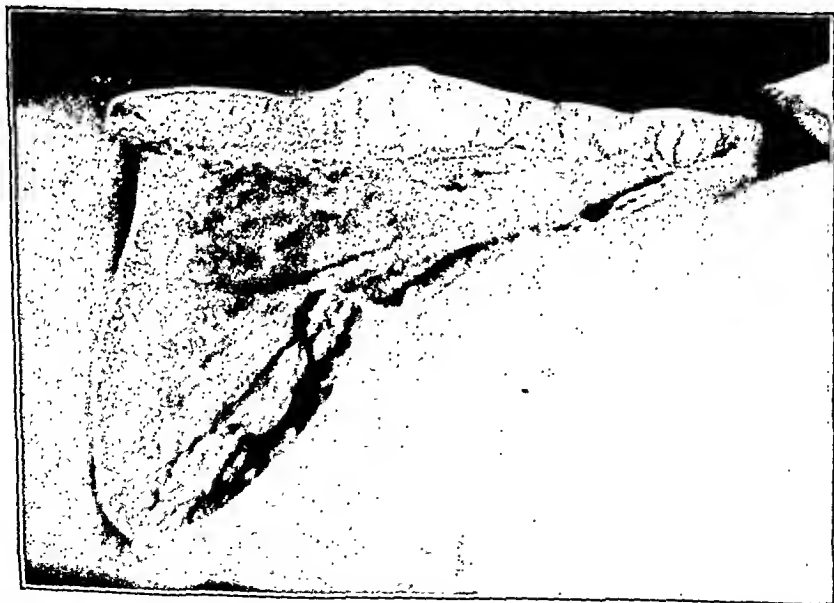


Fig. 24.—(Case 5) Lateral view, six days after admission and five days after excision. Wound appears clean.

although there seemed to be some healing of the ulcer, the infection spread into the flank and up above the umbilicus. She ran a high temperature, varying from 101° to 103° F.; she gradually lost weight, strength, and courage and was finally sent to the Presbyterian Hospital where she arrived in very poor condition. Figs. 22 and 23 show the extent of the wound at that time. There was a large defect in the skin over the right lower quadrant with rolled-in skin edges which were deeply undermined. One small ulcer had formed by perforation from beneath on the inner margin of the wound, another on the lower margin, a large daughter ulcer was present in the region of the anterosuperior spine, with a bridge of skin, completely surrounded by epithelium, between it and the main ulcer. Above the umbilicus there was extensive undermining with threatened perforation, and in the flank the undermining had spread and broken out as an irregular, roughly circular ulcer, with a considerable amount of adherent sub-

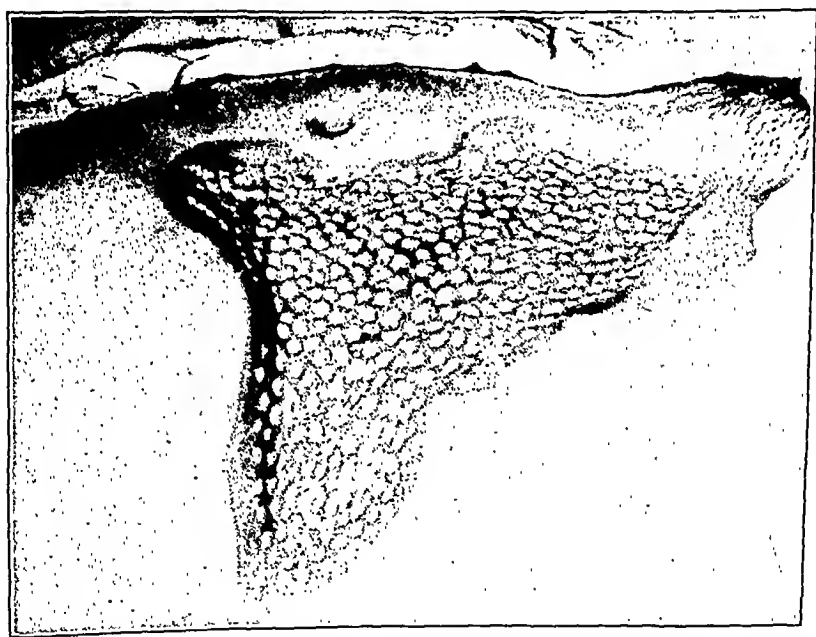


Fig. 25.—(Case 5) Lateral view fourteen days after partial skin graft (on lateral portion) and eight days after the completed skin graft. At this stage the new batch of zinc peroxide was applied, which proved to be ineffective.

taneous slough, but without gangrene of the skin. Since it was apparent that no surface application of zinc peroxide could reach the infection, it was necessary to excise the lesion completely. This was done to the extent illustrated in Fig. 24. All of the indurated tissue was excised, exposing the external oblique muscle. In the region of the umbilicus the margin of excision was narrow, as was also the case in the groin. The wound was immediately flooded with a crenny suspension of zinc peroxide, packed with fine-meshed gauze soaked in the same material, and covered with vaselino gauze. The infection cleared up very rapidly, granulations sprang up netively from all parts of the wound, and new skin began to grow in from the margins. In one spot opposite the umbilicus where the infection had begun to burrow, careful application of zinc peroxide controlled the extension. Sixteen days after the excision a portion of the wound was covered with small pinch grafts which maintained their circulation, and



FIG. 26.—(Case 5) Recurrence in center of lesion following the use of ineffective zinc peroxide.

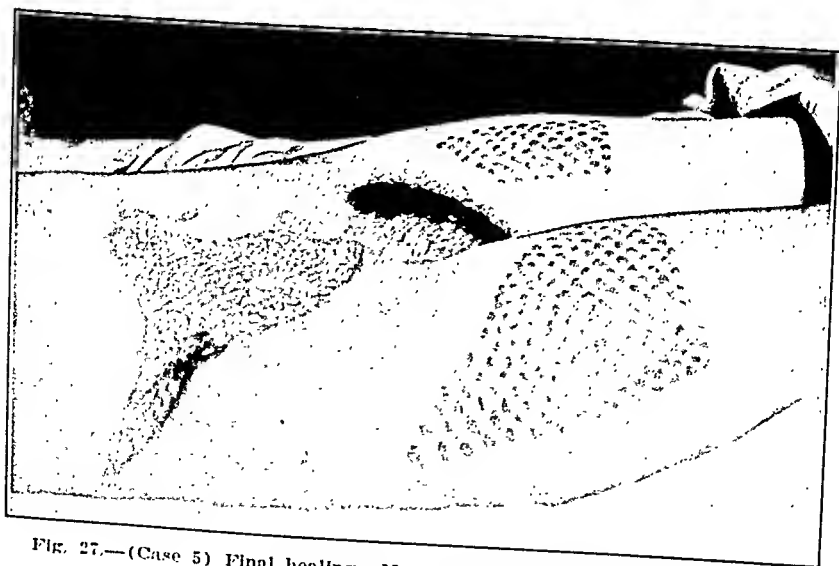


FIG. 27.—(Case 5) Final healing. Note the contraction of the whole area.

six days later the remainder of the wound was covered with grafts (Fig. 25). The healing progressed satisfactorily and preparations were made for the patient to go home. Before this had been accomplished, however, our supply of the old effective zinc peroxide, which we had been using, became exhausted and the hastily prepared material, which was coarse and sandy, was used. Almost immediately a small spot appeared in the center of the grafted area where the organisms burrowed down between the external and internal oblique muscles, and even close application of the zinc peroxide failed to stop the invasion of the organisms which continued even after the application of zinc peroxide which we knew to be effective (Fig. 26). Several local, conservative excisions of this area were required before the infection came under control, but this was finally accomplished. Although the organism recovered from this lesion proved relatively susceptible to the zinc peroxide in the test tube, it was very persistent in this region of recurrence, evidently going down into a fascial space and preventing close contact with the zinc peroxide. Just before closure, however, the hemolytic organism was completely replaced by the aerobic green streptococcus, and soon afterward the wound closed over (Fig. 27).

CASE 6. M. A., aged thirty-seven years. Unit History No. 458354. Admitted July 9, 1935; discharged Nov. 3, 1935.

History.—Nine months previously the patient had been operated upon for what was thought to be chronic cholecystitis. An oblique incision was made in the right upper quadrant and a long, undescended appendix was found to be the cause of his symptoms. This was removed and the abdominal wall was closed without drainage. On the tenth day the wound broke open, revealing a deep infection, and it continued to drain copiously for a number of weeks. Gradually a large ulcer developed, with extensive undermining of the skin margins. The patient ran a temperature of 100° to 104° F. All sorts of local and general measures were used in an attempt to combat the infection, but it continued to spread in spite of everything that was done. He was sent home from the hospital and was treated by his family physician who communicated with me about the case, described the course of events, and stated that he thought that it corresponded to the cases that I had previously described. I advised the use of zinc peroxide, and I was informed that the lesion showed prompt improvement following its application, but while it seemed to improve in certain areas the infection continued to spread in others. Because of this lack of improvement I went to Pittsburgh to see the patient and again concluded that the extent of the lesion and the depth of the undermining prevented adequate contact with the medicine. I advised an excision of the lesion, which had by that time extended upward beneath the costal margin and exposed a portion of the perichondrium of the fused cartilages. The lesion was excised, however, without exposing the cartilages, and the operation seemed to be adequate at the time. This was followed with very careful applications of zinc peroxide, and the patient showed immediate striking improvement; his temperature fell, granulations sprang up all over the surface of the wound, and after sixteen days his surgeon decided to skin-graft. At that time he stopped the use of zinc peroxide. The skin grafts appeared to do well for several days, but after about a week the infection again became active, the skin grafts melted away, the temperature rose, and the skin margins became further undermined. The patient had lost one hundred pounds since the onset of his illness, he was running a high fever, and his prostration was profound. His morale had been completely shattered, and he had lost all expectation of recovery.

The patient was then sent to New York. He arrived in very poor condition; and he had no recollection of the trip. The lesion showed the condition illustrated

in Fig. 28. In the right upper quadrant and right flank there was a large ulcer with grayish surface granulations and rolled-in skin edges with moderate undermining in several places. There was a large area of costal cartilage exposed and an undermining of the subcostal tissues. Likewise, the perichondrial tissues were undermined, exposing an eroded cartilage. It was decided to excise again the overlying flaps and the infected margins. In order to avoid infection of the ribs in the presence of this extensive involvement of tissue, it was decided to cut the cartilage across cleanly near the bone as a temporary measure, with the idea of later removing the cartilage after the infection had been reduced. After excision the wound was flooded with a creamy suspension of zinc peroxide in water, packed with a fine-meshed gauze soaked in the same material, and sealed with vaseline gauze. The wound cleared up rapidly; granulations took on a bright red appearance and sprang up from the recently infected areas, and new skin began to grow in from the margins. Frequent cultures showed a pro-

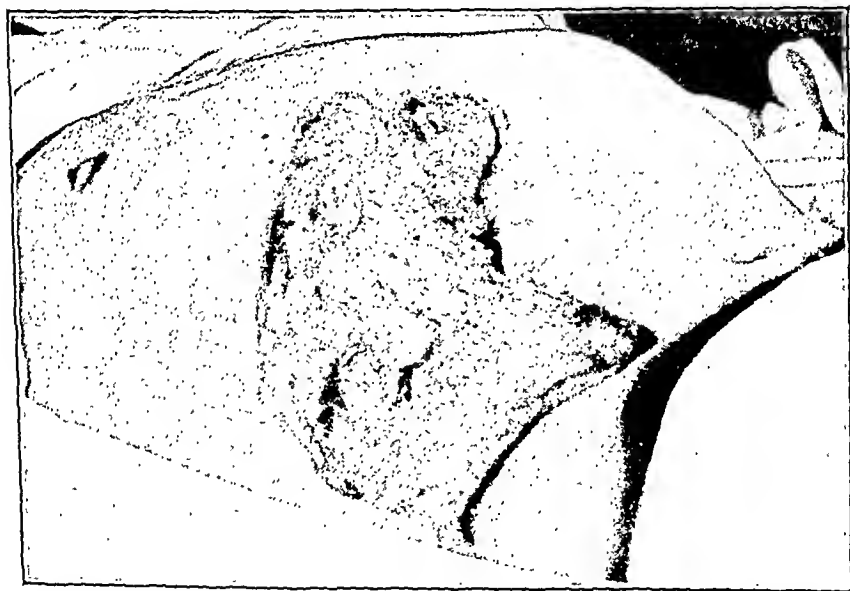


Fig. 28.—(Case 6) Infection of wound following abdominal operation (undescended appendix). On admission, nine months after onset of disease. Note the gelatinous granulation tissue; the rolled-in, undermined skin margins; the exposed cartilage of the twelfth rib; and the exposed perichondrium of the fused ribs.

gressive diminution of the infection, and two weeks after the preceding operation all of the exposed cartilages were removed from the ribs, leaving the bone exposed (Fig. 29). This very promptly granulated without any evidence of invasion of the bone itself. Skin grafts were then applied to the wound in two sittings, and only two or three failed to maintain their nourishment. They soon became fused and began to produce new epithelium. In places, however, the new skin showed a tendency to erode (Fig. 30). This was thought to be due to the mechanical rubbing of the wound by the dressing, resulting from the movements of respiration. Likewise, on two occasions small hematomas formed in the granulation tissue. Just at this time the supply of the old zinc peroxide was exhausted, and the new, hastily prepared, sandy, yellowish material was used. From that time, coincidental with the bad effects produced in the two preceding cases, the wound showed renewed activity of the infection. Pain developed un-

der the left costal margin, and gradually a swelling appeared in that region. It was evident that the infection had undermined the sternum and spread to the other side. Although within a week material known to be effective was applied, the damage had been done, and it was necessary to remove the cartilage of the sixth, seventh, eighth, ninth, and tenth ribs of the left side. When this had been done, the wound responded very nicely; new granulation tissue grew up from the recently cut surfaces and from the bone, and healing progressed steadily (Fig. 31). In the meantime the DuPont Company sent us another batch of zinc peroxide which they said had been made in exactly the same manner as the preceding batch. Although we still had a fair quantity of the effective material, we felt that we should take the opportunity of comparing it with the new product in the same patient. Half of the wound was therefore treated with each prep-



Fig. 29.—(Case 6) Seventeen days after admission. The cartilages of the fifth to the twelfth ribs have been removed, as well as two undermined areas on the opposite skin margin.

aration. We soon found that the two batches had very different physical properties. The new material produced a hard plasterlike cake in the wound, and after three days of its application to the right side, the infection became more active again in that region. The new skin which had formed began to melt away, the margins in several places began to be undermined, and although the effective material was then applied, the retrogression of healing continued for ten days. After the careful application of the effective zinc peroxide, however, the infection again came under control, and from that time the progress of healing was steady. The area on the left was covered with skin grafts which fused gradually and covered over the whole area. Final epithelization, after the organism had disappeared from the wound, was accelerated by the use of oxyquinoline gauze. Fig. 32 shows the final stage of wound healing.



Fig. 30.—(Case 6) Thirty-seven days after admission, twelve days after first skin graft, and five days after second graft.



Fig. 31.—(Case 6) During a period of application of ineffective zinc peroxide the infection spread under the sternum to the opposite side, requiring the removal of the sixth to the tenth costal cartilages on the left. The picture was taken nine days after the operation.

CASE 7.—B. K. B., aged twenty-nine years. Unit History No. 458459. Admitted to hospital July 14, 1935; discharged October 21, 1935.

History.—Fifteen months before admission and one month after a blister had formed on the lower leg from the pressure of a brace, the patient developed a swelling in the right groin which was thought to be a femoral hernia. It did not respond to local applications, and after two or three days it was operated upon. It was found to be a swollen lymph gland which was removed, and the wound was closed. On the second postoperative day the wound became painful, swollen, and tender, and the patient's temperature rose to 103° F., following chills. When the wound was opened, a purulent exudate was found. Infection spread very rapidly in all directions, with a necrosis of the subcutaneous tissues.



Fig. 32.—(Case 6) Final healing of the wound four months after admission.

On succeeding days several attempts were made to halt the spread of the infection by excising the involved skin. The undermining processes, however, continued spreading toward the groin, toward the vulva, and up under the inguinal ligament to the abdomen. Gradually the ulcer enlarged in all directions, the skin edges became excessively undermined, and the margins rolled in. All kinds of local and general treatments, including Dakin's solution, boric acid solution, peptone broth, blood transfusions from vaccinated donors, direct autogenous vaccines, etc., were tried, without effect. The wound was very painful and the temperature ranged from 98° to 101° F. This condition steadily became worse over a period of nine months. Sumner Koch saw the case several times in consultation and suggested that Grier communicate with me. The history of the case seemed definitely to classify it in the group of chronic undermining ulcers and, at my

suggestion, Grier began to use zinc peroxide. Up to that time the patient had been steadily going downhill, and transfusion seemed to be the only means of treatment which was able to halt her rapid loss of strength. Under the zinc peroxide, however, she showed prompt improvement. The surface granulations took on a healthy appearance, but the progress of the infection was not completely checked. Grier found difficulty in applying the zinc peroxide beneath the undermined edges, and he found that the material dried and caked in the wound. The patient made steady improvement for a period of two months, the undermined skin edges filled in, but several deep sinuses persisted, and in these regions the infection continued to spread. Several times the zinc peroxide was given up and other antiseptics were substituted, but invariably the lesion became worse

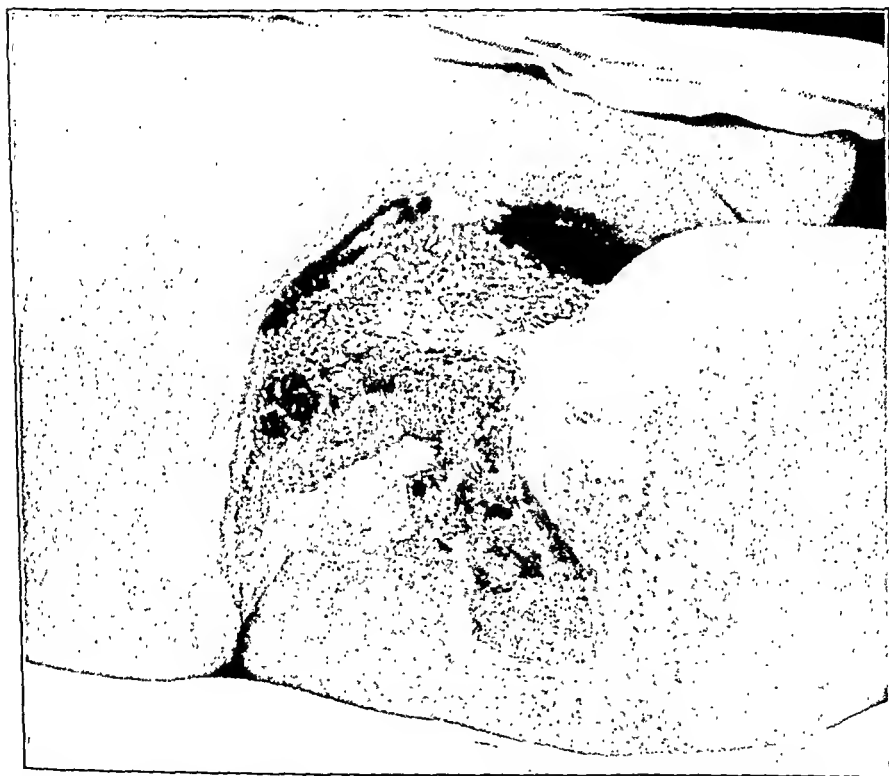


Fig. 33.—(Case 7) Lymph gland type. On admission, fifteen months after the onset of the disease. Note the rolled-in, undermined skin margins.

under such treatment. Finally, a skin graft was attempted, but it was not successful. Grier became convinced that the zinc peroxide was the only medication that would hold the infection in check, but still the wound did not clear up. I offered to go out and see the patient, approximately seventeen months after the onset of the disease. I found that the zinc peroxide was not reaching the depths of the infection and that it had spread across the mons veneris to the opposite side, had undermined the vulva tissues on both sides, and had spread down under the thigh in the region of the anterosuperior spine and the groin. Since it was obvious that a more radical procedure was necessary, the whole lesion was opened widely and all the infected surfaces were left exposed, except for the undermining on the mons veneris. It was decided to make a contralateral incision and

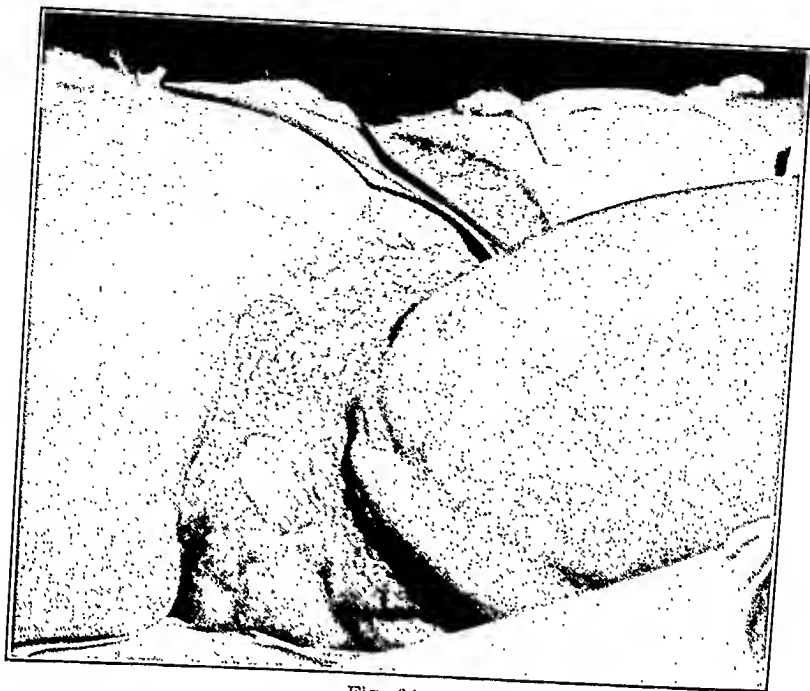


Fig. 34.

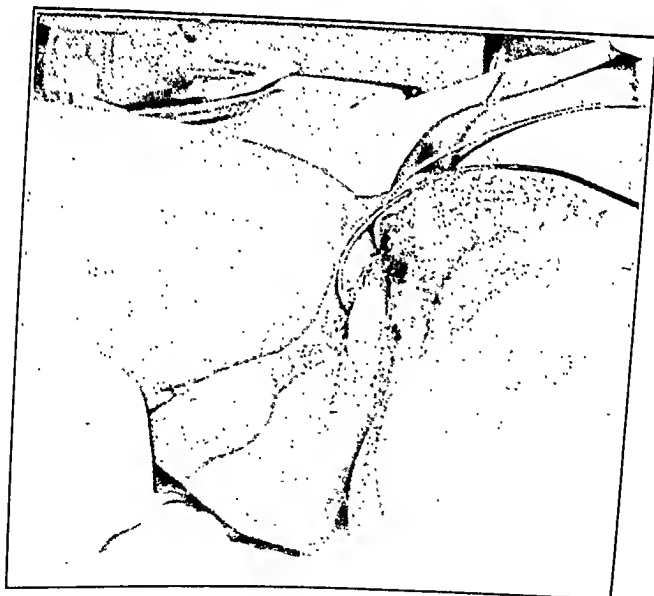


Fig. 35.

Figs. 34 and 35.—(Case 7) Forty-five days after admission; twenty-four days after skin graft. Note the general contraction of the wound. The catheters enter the sinus under the gracilis muscle, which appeared soon after the application of ineffective zinc peroxide, but finally closed when effective material was applied without further excision.

attempt to get contact beneath the skin flap. Following this operation the patient had a very severe reaction, and erysipelas developed, which spread rapidly down the thigh. When she had recovered from the erysipelas, she made rapid progress: granulations grew up from all parts of the wound surface, the wound began to contract, and new epithelium began to grow in from the skin margins. On the inner side of the thigh, however, the infection again spread downward, and Grier sent the patient on to New York where she was admitted to the Presbyterian Hospital.

At that time the wound had the appearance shown in Fig. 33. There was a large granulating area in the right groin which extended up on the abdominal wall and down onto the thigh. In certain portions of the margin there was very extensive undermining, and the skin, which was rolled in, was in contact with the granulation tissue. In other places the skin edges were not undermined, and new skin was growing from these adherent margins. There was a subcuta-



Fig. 36.—(Case 7) Final healing two and a half months after admission.

neous spread, however, on the inner side of the thigh beneath the vulva. These areas were further opened and the rolled-in skin margins were trimmed off. It was then possible to get intimate contact everywhere with a creamy suspension of zinc peroxide in distilled water; the wound was packed with fine-meshed gauze soaked with the same material, and this was sealed over with fine-meshed gauze impregnated with zinc oxide ointment. The granulations promptly became pink, new skin began to grow in from the margins, and on the twenty-first day after admission the whole area was covered with pinch grafts taken from the left thigh. These were held in place by a single layer of coarse-meshed gauze which was sealed to the skin margins with collodion. Then compresses of fine-meshed gauze soaked in saline were applied and sealed with vaseline gauze. The donor area was dressed with zinc peroxide suspension and sealed. After twenty-four hours the saline compresses on the grafted area were removed, the wound was flooded with a dilute suspension of zinc peroxide and again sealed for twenty-four hours, at which time all the grafts had taken on a pink appearance. The

coarse-meshed gauze was then removed and thereafter the wound was dressed in the usual way. Healing progressed steadily thereafter; the grafts promptly fused with each other and with the skin margins, and everything seemed very favorable. Before complete healing had taken place, however, the old effective zinc poroxide, which we had been using, became exhausted and we applied the hurriedly prepared, coarse, sandy mixture, which was used in the three preceding cases. Within a few days there was very evident activity of the infection; the hemolytic streptococcus, which had disappeared, reappeared, and sinuses were apparent where the organism had burrowed during the interval of the application of the noneffective material. One sinus was particularly distressing, as it had burrowed down from the surface and made a communication beneath the gracilis muscle (Figs. 34 and 35). A few days later the patient suddenly developed chills and high fever. Erysipelas appeared at the lower margin of the wound and extended rapidly down the thigh and leg to the toes. In my absence, she was given a treatment with ultraviolet light, to which she had a very severe reaction, developing an extensive burn all over the anterior portion of the thigh and leg, and the posterior surface of the leg. She suffered intense pain and a high fever, and was utterly miserable during this time. The wound became edematous and some of the new epithelium dissolved. It gradually subsided on the thigh, although deep sinuses formed in the calf and in the lateral surface of the ankle above the malleolus and on the dorsum of the foot, which required incision. These lesions were treated with zinc peroxide and gradually cleared up. The wound healing continued, the sinuses closed, and finally the whole area became covered with epithelium (Fig. 36).

CASE 8.—C. B., aged thirty-nine years. Unit History No. 475112. Admitted to Presbyterian Hospital Dec. 23, 1935; discharged March 4, 1936.

History.—A year and a half before admission the patient received a small abrasion on the right forearm, and a few days later developed a gland in the axilla. This gradually softened and was opened by his local physician. Pus was released but another gland developed, below the first one, on the chest wall, beneath the margin of the pectoral muscle. Several days later this was also opened and both wounds continued to discharge purulent material, showing no tendency to heal. Finally the infection began to undermine the skin. The lesion spread forward beneath the right breast, upward into the axilla, beneath as well as superficial to the pectoral muscle, and likewise downward and backward on the chest wall. The edges became extensively undermined, and infection broke through the deep surface of the skin, forming daughter ulcers below and to the inner side of the right breast and up in front of the right shoulder. He was treated with all sorts of antiseptics, but nothing seemed to check the infection. He was then sent to New York where John Joseph Eller, a dermatologist, made a diagnosis of syphilis. Although there had been no history of syphilis, the Wassermann was 2+. Very intensive antisyphilitic treatment caused no improvement in the lesion, and the Wassermann remained unchanged.

Eller then referred the patient to me, and he was admitted to the Presbyterian Hospital when the condition had reached the stage shown in Fig. 37. On the chest wall near the axilla there was a large irregular oval ulcer, measuring approximately 6 by 15 cm., with the long diameter transverse. This was bridged by a strip of skin which ran transversely, dividing it into two parts. Below the main ulcer there were three small daughter ulcers which had evidently formed from invasion of the organism from the surface. There was extreme undermining posteriorly, extending backward about 6 to 8 cm. There was also undermining up into the axilla and under the pectoral muscle. At the inner side of the nipple

there was another ulcer with undermined edges which was connected with the main ulcer by a sinus beneath the nipple. The margins of this daughter ulcer were considerably undermined on the inner and upper sides. In the infraclavicular region there was another daughter ulcer, evidently produced by auto-inoculation. This had deep undermined margins but was partially covered by a thin, tenuous, weblike veil of thinned-out skin, perforated in several places, leaving bridges between the openings; and epithelium grew on the deep as well as on the superficial surface. On the anterior part of the shoulder, over the pectoral muscle, there was another smaller oval ulcer with undermined margins. In several places the skin was rolled under, and in the center of the main ulcer there was a deep area of greenish gray granulation tissue extending down between two of the ribs. The first procedure was to cut off the bridge of skin across the ulcer, which permitted a better application of the medication to the undermined flaps. We decided to avoid a radical procedure at first because we



Fig. 37.—(Case 8) Lymph gland type. On admission, eighteen months after the onset of the disease. Note the bridge of skin and the daughter ulcerations, some formed from within and others from without. There is extensive undermining up over the pectoral muscle and posteriorly, moderate undermining everywhere else.

were anxious to conserve as much as possible of the skin of the axilla. The zinc peroxido, therefore, was applied in a creamy suspension, the wound was packed with fine-meshed gauze soaked with the same material, and this was sealed over with fine-meshed gauze impregnated with zinc oxide ointment. Granulations at once began to take on a pink healthy appearance; the undermined flaps began to seal down and new skin began to grow in from the margins (Figs. 37 and 38). The weblike skin over the daughter ulcers on the inner side of the breast and in the infraclavicular region was trimmed off because the epithelium had grown on the deep surface, and the skin margins were rolled under. When this had been done these ulcers promptly closed. At the end of the fourth week the rolled-in skin was also trimmed back from the margin of the main ulcer, and the deep portion of the infection which went down between the ribs was completely excised. The undermining in the axilla steadily filled in without any radical operation in this area. Under the breast a small sinus, through which

the medial daughter ulcer communicated with the main ulcer, persisted, but this was not opened because we felt we were getting good contact and hoped that it might close following irrigation with zinc peroxide. On the tenth day after excision of the margins, the area was covered with skin grafts of the Reverdin type. These were held in place with a single layer of coarse-meshed gauze sealed to the neighboring skin with collodion, but because of the concavity of the axilla and the movement of the arm, it was not possible to maintain contact with all of the grafts, and about six out of thirty were lost. The others, however,



Fig. 38.—(Case 8) Twenty-five days after admission. The wound has cleared up considerably without extensive excision, but sinuses persist under the breast and down between the ribs. Undermining persists posteriorly and up toward the pectoral muscle.

soon fused with each other and with the neighboring skin. The sinuses into the axilla and beneath the pectoral muscle gradually closed, but the inframammary sinus persisted (Fig. 39). It was then decided to hasten the closure of this sinus by opening it widely. There were evidently nooks and crannies which were not getting proper contact. When this sinus was opened, the granulations soon took on a pink appearance, the wound began to contract, and new skin grew in from the margins. During the course of treatment the hemolytic organisms very



FIG. 39.—(Case 8) Two months after admission; three weeks after skin graft. The sinus under the breast and the small one down between the ribs persisted and had to be excised.



FIG. 40.—(Case 8) Final healing with perfect function of arm.

the medial daughter ulcer communicated with the main ulcer, persisted, but this was not opened because we felt we were getting good contact and hoped that it might close following irrigation with zinc peroxide. On the tenth day after excision of the margins, the area was covered with skin grafts of the Reverdin type. These were held in place with a single layer of coarse-meshed gauze sealed to the neighboring skin with collodion, but because of the concavity of the axilla and the movement of the arm, it was not possible to maintain contact with all of the grafts, and about six out of thirty were lost. The others, however,

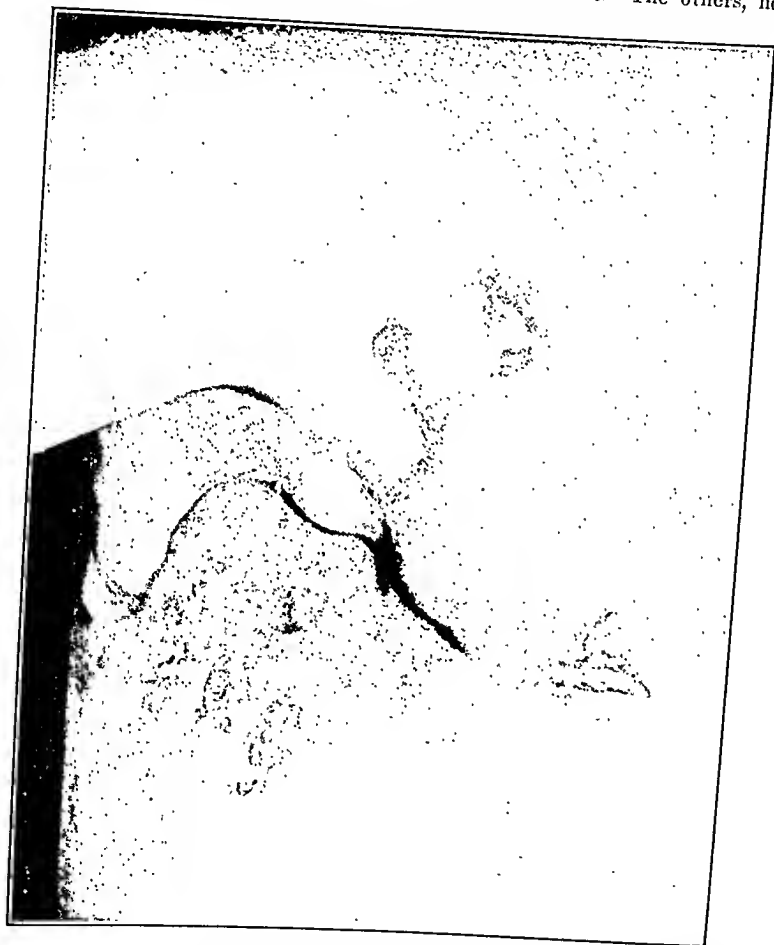


Fig. 38.—(Case 8) Twenty-five days after admission. The wound has cleared up considerably without extensive excision, but sinuses persist under the breast and muscle.

soon fused with each other and with the neighboring skin. The sinuses into the axilla and beneath the pectoral muscle gradually closed, but the inframammary sinus persisted (Fig. 39). It was then decided to hasten the closure of this sinus by opening it widely. There were evidently nooks and crannies which were not getting proper contact. When this sinus was opened, the granulations soon took on a pink appearance, the wound began to contract, and new skin grew in from the margins. During the course of treatment the hemolytic organisms very

lieving that the case belonged to this group, I advised the use of zinc peroxide. The lesion very promptly showed a favorable reaction to the treatment. Active granulations appeared and new skin began to grow in from the adherent margins. The infection, however, continued to spread in certain directions, and the patient finally returned to Chicago and put himself under Sumner Koch's care. Again, various antiseptics were applied; zinc peroxide was used on several occasions, but not consistently, and the infection spread, particularly on the outer side of the thigh, burrowing down between the biceps muscle and the bone. In spite of



FIG. 41.—(Case 9) Contamination of an abrasion. On admission, sixteen months after the onset of the disease. Medial view. Note the absence of new epithelium at the skin margins, which are moderately undermined in several places.

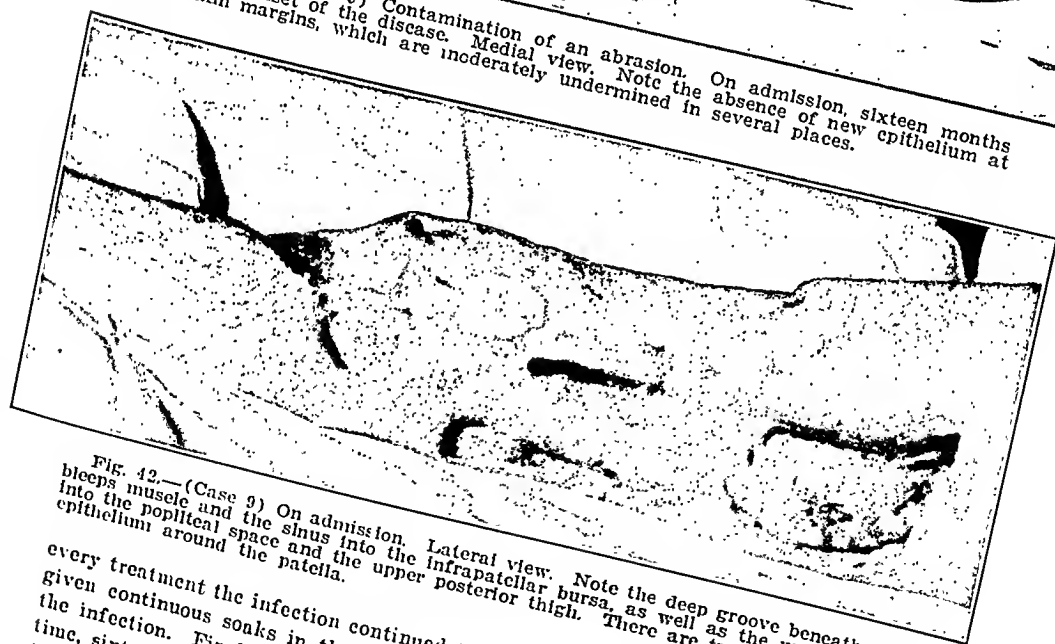


FIG. 42.—(Case 9) On admission. Lateral view. Note the deep groove beneath the biceps muscle and the sinus into the infrapatellar bursa, as well as the undermining into the popliteal space and the upper posterior thigh. There are two islands of new epithelium around the patella.

every treatment the infection continued to advance. At one time the patient was given continuous soaks in the tub, but nothing seemed to halt the progress of the infection. Finally, after five months, Koch sent him to New York. At this time, sixteen months after the onset of the infection, the lesion appeared as is shown in Figs. 41 and 42.

There was a large ulcer of the left thigh and knee region, very irregular in shape, involving anterior, posterior, and lateral surfaces. In several places on

promptly disappeared from those portions of the wound which were getting the best contact with the medication, and were replaced by green aerobic streptococci. For a considerable time, however, the hemolytic organism persisted in the sinus under the breast and in the central depression between the ribs. When these were opened widely, application was more effective, and healing finally took place. One of the small daughter ulcers on the chest wall, which we thought had formed by inoculation from without and which showed no deep connection with the main ulcer, persisted after all the rest of the wound had healed, and the cultures remained positive until it was completely excised. Within three days after this excision the culture became negative, and the wound rapidly closed (Fig. 40).

CASE 9.—G. R., aged eighteen years. Unit History No. 467841. Admitted to Presbyterian Hospital October 20, 1935; discharged August 4, 1936.

History.—Sixteen months before admission this boy fell from a bicycle and abraded the outer side of his left knee. Although it was superficial, the wound became infected. In spite of the application of various antiseptics while under the care of several doctors, the wound showed no sign of healing for a period of two months. Then three small lesions appeared in the neighborhood of the central ulcer. Ultraviolet light was then applied, and there seemed to be an effort toward wound healing. The small lesions persisted, however, and some weeks after that a physician probed them and found extensive undermining. Merthiolate, mercurochrome, Dakin's solution, bacteriophage, and balsam of Peru were applied again and again, without effect. At times there seemed to be some healing, but the lesion slowly and relentlessly spread. One day the wound was accidentally hit with a tennis racket, and the infection immediately took on renewed activity. Another surgeon was called in who decided to incise the lesion. After removing some of the deeply infected tissues, he sutured the skin together. This very promptly broke down, and the lesion took on a much more active spread; the leg began to swell, and the glands of the groin became enlarged. The infection spread across to the inner side of the knee. The patient was taken into the University Hospital in Chicago, where further incisions were made. Boric acid and Dakin's solution were used locally and ultraviolet light as well. The leg became steadily worse, the tissues sloughed away, and the ulceration spread upward over the anterior surface of the thigh. He was then treated by a succession of doctors, each of them trying something new. Potassium permanganate was used for three weeks, without result. Serum and tin were tried for six weeks more, without result. The original family physician then took over the case again and applied silver nitrate, Dakin's solution, antiphlogistine, ichthyol, mercurochrome ointment, boric acid, and potassium permanganate, in order, all without avail.

During the treatment the ulcer steadily progressed and daughter ulcers formed by perforation of the skin from beneath, but in places the wound showed evidence of healing. A culture from the wound was reported negative. The patient was then sent to Phenister, who advised the discontinuance of all local treatment, sent him to Florida, and advised him to leave the wound exposed to the sunshine. The patient carried out this treatment, but the infection steadily progressed, and he was finally taken to the hospital where local treatment with various antiseptics was again used. Several new ulcers formed during this time and a number of relatively limited operations were performed in an effort to open up some of the undermined pockets. Dakin's solution, potassium permanganate, silver nitrate, magnesium sulphate, and boric acid were all tried.

At that stage Duncan Owens of Miami Beach, who was in charge of the case, communicated with me. He reviewed the history and described the lesion. He

day, when the coarse-meshed gauze was removed, all but two of the grafts were pink and firmly adherent (Fig. 43). They became fused with each other and with the surrounding skin in short order. On the eleventh day the rest of the anterior and inner portions of the ulcer, as well as the outer side anterior to the groove, between the bone and the biceps muscle, were covered with skin grafts. Two weeks later the rest of the ulcerated area was grafted. Each time the grafts were successful except for one or two which had been placed in the neighborhood of the remaining deep sinuses. These grafts rapidly fused, and the whole area contracted down very satisfactorily, but the infrapatellar pouch and the groove in front of the biceps muscle were slow to heal (Fig. 44). After about a month, however, the infrapatellar pouch closed completely, and the limb used to a dependent position. We then decided to begin to get the groove showed evidence of contraction. Gradually the patient prolonged the period of dependency of the foot at increasing angles. The culture from the groove showed a steady reduction of organisms, and the application of zinc peroxide was stopped for a period of five days with the hope that the wound would

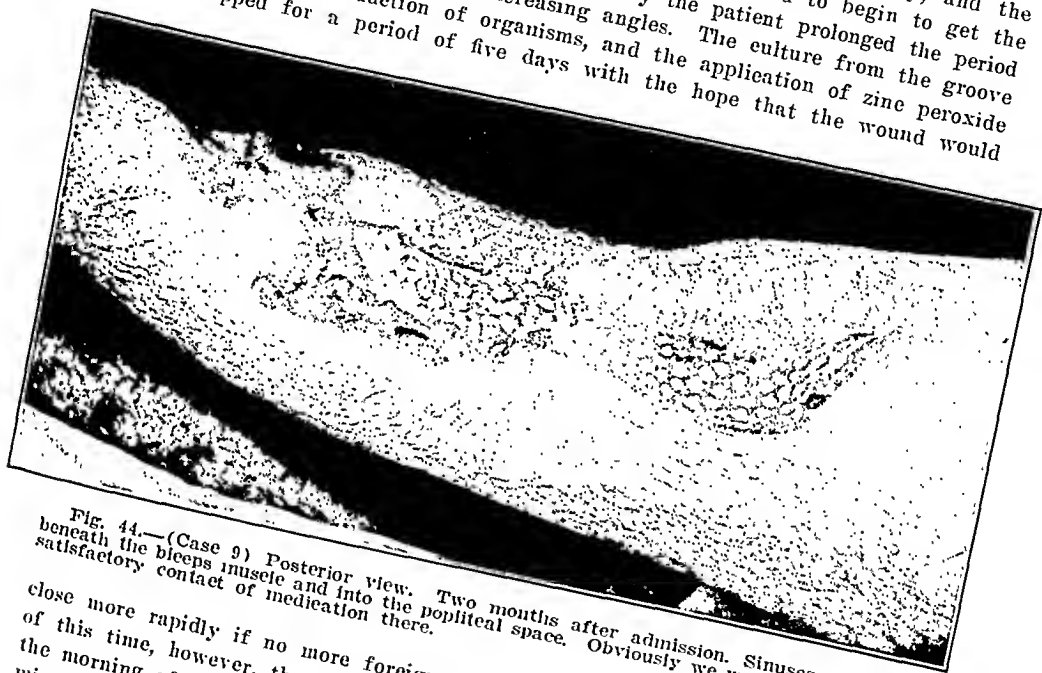


Fig. 44.—(Case 9) Posterior view. Two months after admission. Sinuses persist beneath the biceps muscle and into the popliteal space. Obviously we were not getting satisfactory contact of medication there.

close more rapidly if no more foreign substance was introduced. At the end of this time, however, the patient began to have pain in this region, and on the morning of the sixth day, after he had had his foot on the floor for five minutes every hour, the tissues became swollen, edematous, and discolored. It was evident that the infection was active again in the deep cavity beneath the biceps muscle. The application of zinc peroxide was started again and the leg was elevated, but the groove enlarged and the tissues internal to the biceps muscle in the popliteal space began to swell, indicating that the popliteal vessels made pronching the surface in this region. The proximity of the popliteal space had to be opened and explored. We debated whether to excise a portion of the biceps muscle, but when the incision was made, a cavity was found in the popliteal space surrounding the peroneal nerve. This cavity was opened and the roof removed, leaving the peroneal nerve, covered by some granulation tissue, exposed (Fig. 45). The area was cleaned out, as was the infected area beneath the biceps muscle, and although we realized that we had compromised with the

the margin there was moderate undermining of the skin; in other places, new skin was growing out from the margin over the granulation tissue. Below the patella there were three sinuses which communicated with one another and entered into the infrapatellar bursa. On the outer side of the thigh there was a long deep groove between the biceps muscle and the bone where the infection had burrowed deeply. There was also an extensive burrowing upward posteriorly from the upper limit of the ulcer, with a large area of indurated tissue beneath the skin. An x-ray film revealed no involvement of the bone or the joint. It was evident that there were portions of the lesion which would require excision, but because of the patient's poor condition, it was decided to be conservative for a time. The whole area was flooded with a creamy suspension of zinc peroxide in distilled water. Fine-meshed gauze soaked in the same material was laid over the surface and packed under the overhanging margins, and the whole area was then sealed with fine-meshed gauze impregnated with zinc oxide ointment. On several occasions large hematomas formed in the superficial layers of



Fig. 43.—(Case 9) Fifteen days after admission, six days after the first skin graft and the partial excision of undermined margins. Note the oval area over the femur where a large superficial hematoma had been lifted off the granulation tissue. The infrapatellar pouch was partly opened by cutting halfway across the patellar tendon. We temporized with the undermining in the popliteal region because of the obvious danger.

the granulation tissue; these were thought to be caused by rubbing but were probably due to a spontaneous bursting of new blood vessels. They did not cause serious trouble, for they could be lifted off without great damage to the underlying tissues. On the ninth day six undermined areas were excised, and the infrapatellar bursa was opened by cutting halfway across the patellar tendon. This did not completely expose the cavity but permitted ready access to it. At the same operation the anterior portion of the wound, except for the recently exposed areas, was covered with about two hundred small skin grafts. These were held in place by a single layer of coarse-meshed gauze sealed to the skin margin with collodion. Saline compresses were applied to the surface and covered with vaseline gauze to prevent evaporation. On the day after the operation a thin suspension of zinc peroxide was applied to the grafted area, and on the next

caused moderate suppuration of the wound, but the hemolytic streptococcus never came back. On the eleventh day the femoral artery in the stump blew out; the bleeding was promptly stopped by tourniquet and then by a chromic catgut suture. On the next day we ligated the femoral artery below the profunda. A small lymph gland was found directly over the artery, but it was not disturbed, and

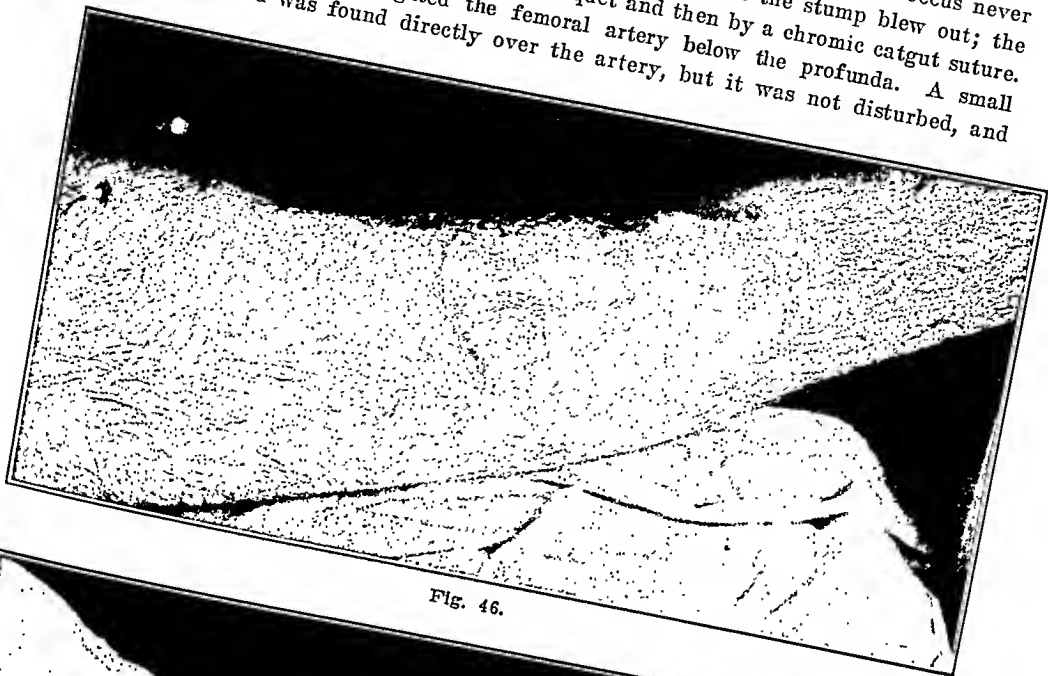


Fig. 46.

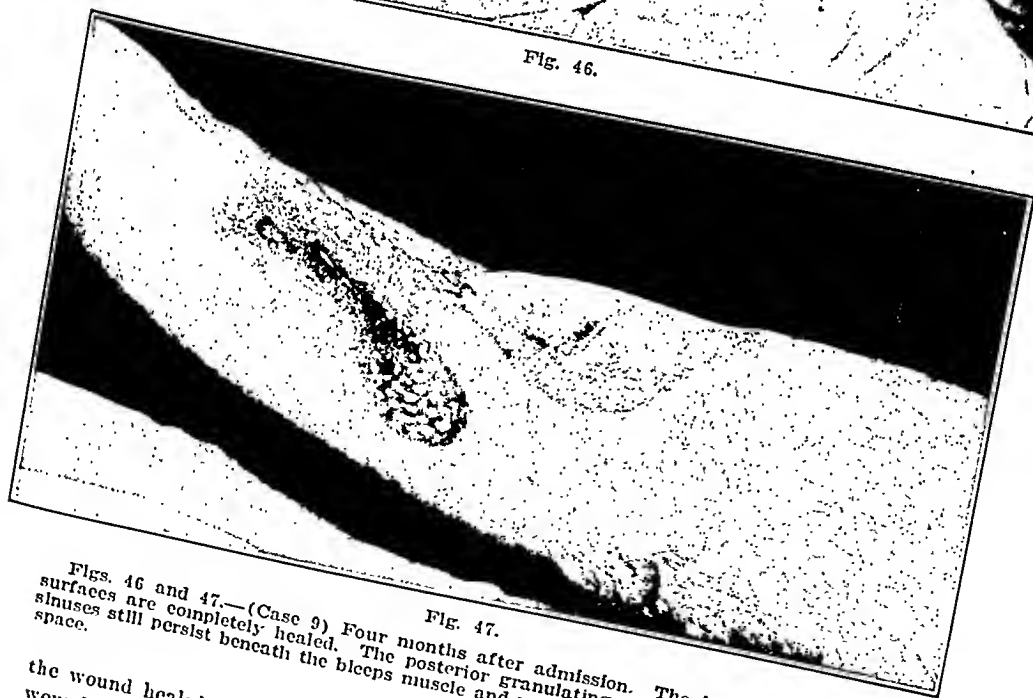


Fig. 47.

Figs. 46 and 47.—(Case 9) Four months after admission. The inner and anterior surfaces are completely healed. The posterior granulating surface has narrowed, but sinuses still persist beneath the biceps muscle and peroneal nerve and into the popliteal space.

the wound healed without any infection. No further hemorrhages occurred, the wound granulated satisfactorily, and on the nineteenth day was covered with small pinch grafts from the right thigh. All but one of these grafts took, and thereafter the wound rapidly contracted and healed over.

infection by this limited procedure, we felt that the only chance of saving the leg was to attempt to get contact with the infection in this way. Granulations grew up rapidly, and the cultures indicated a rapid diminution in the number of organisms. The space between the peroneal nerve and the biceps muscle filled in partly, but sinuses persisted beneath them. Although the front and inner sides were well healed, on the posterior surface healing came to a standstill, but the amount of drainage was minimal (Figs. 46 and 47).

The culture continued to show the hemolytic streptococcus and *Bacillus pyocyaneus*. On a number of occasions we considered a radical procedure, but then we would be encouraged by a diminution in discharge and the closure of one of the sinus openings. After a sinus had remained closed for two or three days, the region about it would swell, become painful, and have to be opened. A small sinus appeared medial to the internal popliteal nerve, indicating activity of the infection in that region (Fig. 48). This sinus closed on several occasions but opened again, and so it went on for six months, while we hoped against hope



Fig. 45.—(Case 9) Three months after admission. Finally a "conservative radical" operation was performed in which we attempted to lay open the popliteal space, as well as the space beneath the biceps muscle, wide enough for complete contact with the medication. The peroneal nerve surrounded by granulation tissue was also undermined. It may be seen at the lower end of the wound.

that the infection would finally come under control. We realized that the popliteal lymph glands were probably involved and we shrank from the consequences of a radical procedure.

At the end of that time, however, it was evident that we would have to make the effort. The popliteal space was opened, the popliteal artery was found to be surrounded by infected tissue which extended down for a short distance between the bellies of the gastrocnemius muscle. Even though the cavity was opened widely, dressings were excruciatingly painful, and it seemed to be impossible to get contact with every portion of the deep surface. After three or four days the wound began to bleed, and five hemorrhages occurred before we were certain that the popliteal artery had blown out. This of course necessitated amputation, which was done at the junction of the middle and lower thirds through the anterior and lateral grafted skin areas. Cultures at the site of amputation were negative at first, but after two or three days *Bacillus pyocyaneus* appeared. This

caused moderate suppuration of the wound, but the hemolytic streptococcus never came back. On the eleventh day the femoral artery in the stump blew out; the bleeding was promptly stopped by tourniquet and then by a chromic catgut suture. On the next day we ligated the femoral artery below the profunda. A small lymph gland was found directly over the artery, but it was not disturbed, and

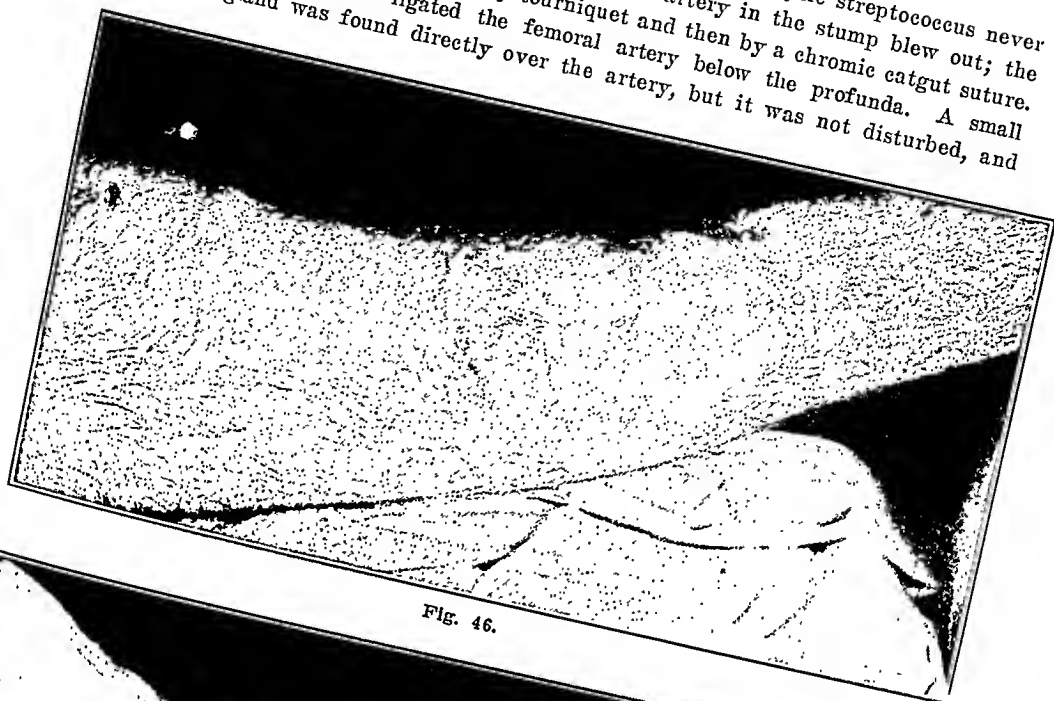


Fig. 46.



Fig. 47.

Figs. 46 and 47.—(Case 9) Four months after admission. The inner and anterior surfaces are completely healed. The posterior granulating surface has narrowed, but sinuses still persist beneath the biceps muscle and peroneal nerve and into the popliteal space.

the wound healed without any infection. No further hemorrhages occurred, the wound granulated satisfactorily, and on the nineteenth day was covered with small pinch grafts from the right thigh. All but one of these grafts took, and thereafter the wound rapidly contracted and healed over.

CASE 10.—L. G., aged thirty years. Office patient, first seen Dec. 24, 1935; discharged on May 5, 1936.

History.—This patient came to the office complaining of an ulcer of the right buttock which had persisted for fifteen months. The lesion, which started as a small pimple, had developed into a boil and had gradually increased in size. It had broken and discharged pus for several weeks before it began to take on the appearance of an ulcer, which gradually increased in size until it was about 3 cm. in diameter, with undermined edges. It was excised by his local physician, and the wound closed with suture, but this broke down and the infection continued to spread. Three months later, a more radical operation was done, and the wound was left open. It then began to heal, but healing soon ceased, and for a period of four or five months it remained relatively inert. During this time all sorts of antiseptics were used, and the patient received a great many treatments with the carbon arc lamp. The Wassermann test was negative, the Frei test was negative, and the biopsy of tissue showed no evidence of tuberculosis or malignancy.



Fig. 48.—(Case 9) Eight months after first admission. Wound all healed except for sinuses under the biceps muscle and peroneal nerve and into the popliteal space. It had remained in status quo for three months, then the exudate gradually increased in amount, and a wider dissection of the popliteal space was decided upon. This was followed in ten days by hemorrhage from the popliteal artery, necessitating amputation.

When the patient came to me, the lesion appeared as shown in Fig. 49. There was an oval transverse ulcer on the right buttock, with undermined rolled-in edges and three small perforations in the skin, coming up from the undermined skin flaps. The ulcer measured approximately $1\frac{1}{2}$ cm. in width and 12 cm. in length. Near the inner end was a small daughter ulcer, evidently not connected with the first but similar in character, with undermining of the skin for a distance of $\frac{1}{2}$ cm. or more. The cultures yielded a hemolytic streptococcus which grew better anaerobically than aerobically. The lesion fitted in with the characteristics of the chronic, undermining, burrowing ulcer, but because of the relative limitations of the lesion it was decided to attempt ambulatory treatment. Zinc peroxide was applied in a creamy suspension, and the undermined margins were packed with fine silk ribbon impregnated with the same material and sealed over with vaseline gauze. The patient showed improvement at once. The under-

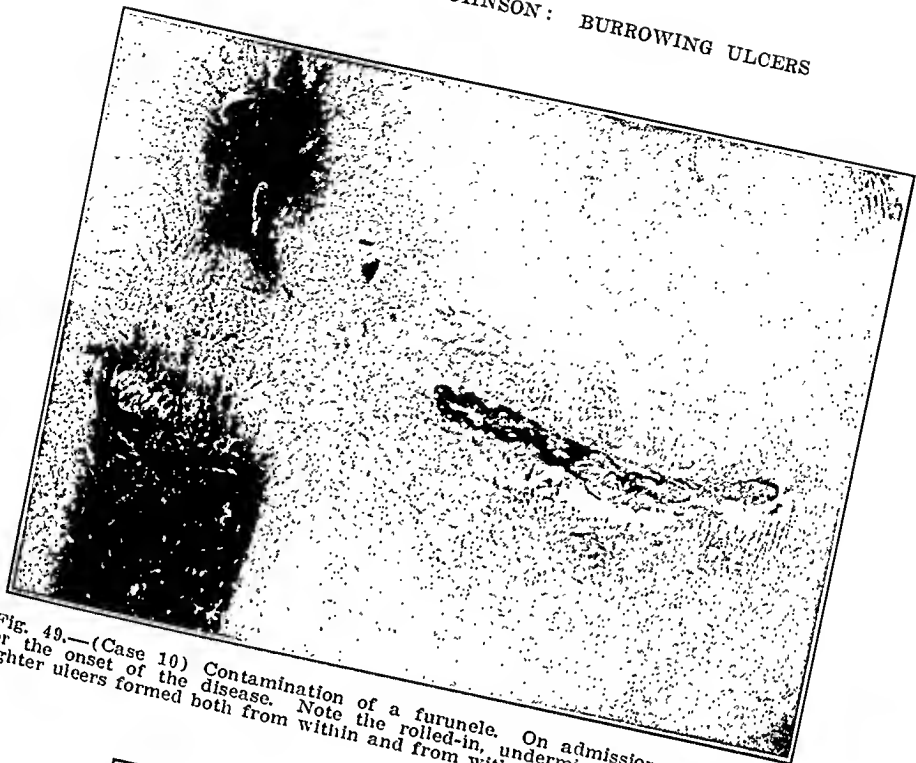


Fig. 49.—(Case 10) Contamination of a furuncle. On admission, fifteen months after the onset of the disease. Note the rolled-in, undermined skin margins, with daughter ulcers formed both from within and from without.

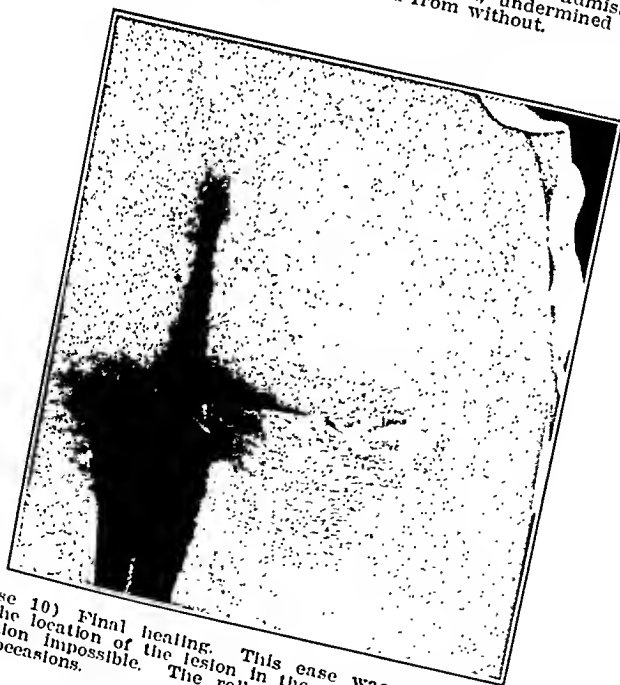


Fig. 50.—(Case 10) Final healing. This case was treated on an ambulatory basis entirely. The location of the lesion in the gluteal fold made constant contact with the medication impossible. The rolled-in skin margins had to be cut back on four different occasions.

mined skin edges sealed down in certain places, but in others the edges curled under so that the epithelium was in contact with granulation tissue. The margins were therefore cut back so as to expose the deeper portions of the wound. It was difficult to maintain contact when he was up and walking about, and the erect position tended to turn in the skin margins still more, so that healing was slow. He was treated at home by his wife, with occasional visits by the family physician, and he was seen in my office once a week. Healing was rapid when good contact was obtained, but slowed down when the margins rolled in. It was necessary on four occasions to cut back these rolled-in skin margins, but healing progressed steadily, and finally, after four months of ambulatory treatment, the lesion healed (Fig. 50).

SPECIAL FEATURES OF EACH OF THESE CASES WHICH ILLUSTRATE
CERTAIN POSSIBILITIES OF THIS DISEASE

In Case 1, the proximity of the sacroiliac joints and the ilia to the original ulcer rendered them particularly susceptible to the invasion of this organism. It is probable that the organism came from the patient's own intestinal tract and was rubbed in by the chafing of the plaster cast. The soft parts responded slowly but, on the whole, satisfactorily to the medication, but the bone, which could not be radically removed, remained infected. It is quite probable that the zinc peroxide used on this patient was not as effective as it should have been. On the other hand, the extensive ramifications of the sinuses in the pelvis may have kept certain portions of the sinuses completely out of reach of the medicine. After the disease had been going on for approximately two years and a half, there was evidence of amyloid degeneration of the internal organs, but the spread of tuberculosis of the lungs was largely responsible for the patient's death. The erysipelas was also a potent factor at the end.

Case 2 illustrates the invasion of an accidental wound by the causative organism. It was accompanied in this case by another anaerobic bacterium which gave the foul odor. This case illustrates also the autoinoculation of the organism into distant areas of the skin, probably by the patient's hands. The undermining of the back of the hand was much more extensive than on the palm, fortunately, and it is possible that the dense mass of the skin of the palm resisted the spread in this direction. It is certain that this case was not treated continuously with effective zinc peroxide. It illustrates how the organism can dig in even in the presence of what seems to be close contact with the medicine and demonstrates also the importance of watching continuously during the course of treatment for such areas of activity. If they appear, they must be given special attention and should be excised before they go very far.

Case 3 illustrates the probable transfer of the infection from one part of the body surface to another. Fortunately, in the axilla the

invasion did not proceed deeply during the course of two years. In the perineal region, however, there were deep sinuses rather than extensive ulcers. This may have been due to the thickness of the skin in these regions. When these sinuses were opened so that close contact with the medication could be assured, they responded favorably. It also demonstrated that it does not save time to temporize with any area however small, where the epithelium has grown beneath a skin flap and lies in contact with granulation tissue. During the healing process this patient developed an irritation of the skin over the hairy portion of the pubis due to an infection of the hair follicles by an accompanying staphylococcus.

Case 4 illustrates the development of multiple daughter ulcers in the neighborhood of the main ulcer by inoculation from without. It illustrates also the extreme danger that exists in cases in which the femoral glands are involved, because of the proximity of the femoral and saphenous veins which may become infected. This case seemed to be under complete control until an ineffective batch of zinc peroxide was used; the infection then spread in the region of the femoral glands, into the deeper tissues, and eventually into the femoral vein, producing a suppurative thrombophlebitis. This is the only case in the series in which the organism was recovered from the blood and produced metastatic lesions. After every operative manipulation there was a sharp fever reaction lasting for several days, and it is quite possible that at such times the organisms might have been recovered if repeated blood cultures had been taken. When a vein becomes thrombosed and an infection invades the clot, it would seem that nothing can stop the spread of the infection except possibly a complete excision of the involved vein, with the probability of an extension further into some of its ramifications even after excision. It was too hazardous to attempt it in this case.

Case 5 illustrates the necessity for wide excision if contact with all of the infected surfaces cannot be obtained conservatively. It also illustrates that the infection can spread down between the muscle layers and resist eradication for a considerable length of time, even with an efficient material. It is quite possible that the frequent attempts at conservative excision did more harm than good; once it is decided to excise, the procedure should be fairly radical, particularly when the infection is spreading down between muscles along fascial planes.

Case 6 particularly illustrates the necessity for complete removal of infected cartilage, and it demonstrates that bone can resist the invasion of the organisms if the infection is reduced to a minimum at the time the bone is exposed to the contamination. This patient was left with a more permanent defect than any of the others because of the loss

of the cartilaginous support of the lower part of the sternum and the fused costal cartilages. It also illustrates the fact that wounds tend to heal slowly if they are constantly moving, and dressings which are sufficiently firm to rub on the surface may erode tender epithelium. It also demonstrates what is frequently seen in untreated cases, namely, that the destruction of tissue in periods of activity of the infection may proceed infinitely more rapidly than the process of repair, and that there is a certain momentum given to the spread of the infection which is difficult to halt even with the application of effective zinc peroxide. This may indicate that at such times the organisms penetrate fairly deeply beneath the surface of the ulcer and are temporarily out of reach.

Case 7 illustrates the fact, as does Case 1, that erysipelas may start and spread from a wound of this type at any time, just as it may from any hemolytic streptococcus infection, and it may recur. In this case infection was in the region of the femoral lymph glands just as it was in Case 4, but fortunately the deep veins did not become involved. There was, however, a tunnel under the gracilis muscle which cleared up by careful application of the medication to the sinus, without radical opening. This should always be tried for a time before a radical procedure is done, which will be mutilative.

Case 8 illustrates the fact that daughter ulcers may be produced either by inoculation of the bacteria from the surface or by undermining beneath the skin. It also shows that the skin can be partially destroyed from beneath but maintain its circulation, and that bridges can be formed with epithelium growing completely around them. Such bridges or skin tabs ought to be removed, for although healing may take place beneath them, it does so slowly, leaving a skin defect which is objectionable. It also illustrates that by persistent care certain deep tunnels may heal without a radical opening, but that this healing is slow, and if a sinus can be opened without too great mutilation of tissues, it will save time in the end to open it early.

Case 9 illustrates how an infection may spread from a trivial abrasion and, in spite of all of the usual methods of surgical treatment, burrow deeply into the subcutaneous tissues and work its way down beneath muscles and involve neighboring lymphatic tissues for a long period of time. The infection in this case burrowed into the infrapatellar bursa but spared the knee joint and the bone. It invaded the popliteal glands, surrounded the popliteal artery and popliteal nerves, and finally perforated the artery but spared the veins. Just when the infection invaded the lymph glands of the popliteal space is uncertain. It may be that a radical dissection of the popliteal space in the early stages of the disease might have saved the leg, but I am inclined to

think that it would have resulted, as it did eventually, in a hemorrhage which would have required disarticulation of the hip joint, with a possible spread up into the pelvic vessels.

The case illustrates the absolute necessity for actual contact with the medication with every part of the infection and the difficulty of controlling the infection in regions where there are lymph glands which have become involved. This case also illustrates the formation of hematomas in the surface layers of granulation tissue and the persistence of *Bacillus pyocyaneus* in the lesion without its being a very important factor in the delay in wound healing.

Case 10 illustrates that this infection may be of low grade and may go on for a long period of time without spreading extensively, but it is characterized by persistency, and its tendency to burrow under the skin causes not only a rolling under of the skin edges, but also multiple perforations of the skin from beneath. I believe that this case was held in check by the large amount of ultraviolet light therapy. This may be due to the fact that the ultraviolet light forms peroxides in the tissue which inhibit, if they do not actually destroy, the organisms.

This case illustrates that certain of these lesions can be controlled under ambulatory treatment if the circumstances require it, but it undoubtedly would have been better to have taken the patient into the hospital where the excision could have been more complete and application with zinc peroxide more satisfactory.

SUMMARY AND CONCLUSIONS

From these cases we may form a composite picture of this disease. It is a chronic infectious process which may occur at any age, in either sex, and on any part of the body surface. It is caused by the invasion of a microaerophilic hemolytic streptococcus which may enter the tissues either through an accidental wound or through an operative wound; or it may invade a lymph gland from a distant source and not produce the lesion at the portal of entry but only after a period of activity within the gland. The lesion is characterized by prolonged suppuration, with the gradual development of an ulcer with undermined, rolled-in skin margins, and sinuses which tend to burrow beneath the skin or into the deeper tissues along lymphatic channels, veins, or fascial planes. The ulcer gradually, but almost irresistibly, enlarges. The base is covered with grayish, gelatinous, anemic, shaggy granulations. Hematomas occasionally form spontaneously in the superficial layers of the granulation tissue. The infection frequently produces daughter ulcers by a perforation of the skin from beneath or by the secondary inoculation of the skin from the surface. If a perforation occurs from within, the daughter ulcer gradually enlarges

and may fuse with the main ulcer or leave a bridge between them, which may become completely surrounded by epithelium on the deep, as well as on the superficial, surface. There is usually a moderate fever and moderate pain in the wound. At times, the temperature may reach 103° F. every day for a period of days, but usually it remains at a lower level. In some cases in which the threshold for sensitivity is low, pain may be intense, and after prolonged illness completely shatter the patient's morale. The infection rarely involves muscle or bone; but when it invades bone, it is almost impossible to eradicate it. The organism rarely invades the blood stream, but occasionally it may be recovered from the blood; and in such cases may produce metastatic foci in other parts of the body. The infection rarely invades the blood vessels, but in long-standing cases it may do so, producing thrombi in them or eroding their walls, causing severe or fatal hemorrhage. In long-standing cases amyloid degeneration of the liver, spleen, and kidneys, may develop. The condition, fortunately, is rare. For this reason, however, it is usually not recognized by any surgeon who sees the case for the first time, and he is likely to treat it as an ordinary infection until its failure to heal makes him realize that he is dealing with an unusual condition. Even then he is not able to make a diagnosis or find out how to treat it successfully because of the meagerness of the literature on this subject. Cases go on for months or years until there is extensive destruction of skin, or a deep penetration resulting in fatal hemorrhage, or the gradual disintegration resulting from amyloid degeneration. Its early diagnosis is therefore of the greatest importance, and this depends not only upon the recognition of the characteristic features of the disease, but also on the early employment of anaerobic methods of cultivation of the bacteria in the wound. In the early stages of the infection the organism is frequently missed because only aerobic cultures have been made, and it is essential that the exudate be planted directly on solid media under anaerobic, as well as aerobic, conditions. It will then be found that the hemolytic streptococci is uniformly present on the anaerobic plates, and when equal quantities are cultivated aerobically and anaerobically, although a few colonies may be found on the aerobic plates, especially in long-standing cases, it will always be found to grow better anaerobically than aerobically. If colonies from the anaerobic plate are transferred again to plates under both anaerobic and aerobic conditions, certain of those colonies will grow only anaerobically.

It would seem to be of the utmost importance, for the recognition of these cases, to have available bacteriologic laboratories, equipped to do anaerobic bacteriology. This applies not only to this disease but also to many types of chronic and acute surgical infections. It would

be well if the American College of Surgeons would require Class A hospitals to be prepared to do adequate anaerobic bacteriology.

With regard to treatment, every conceivable kind of antiseptic has been used in these cases, without effect. The ingenuity of a great many doctors has been taxed to the utmost in an effort to find some antiseptic which will be effective, but almost all of the antiseptics which have been used have had only temporary effect, and the infection has continued to spread in spite of very careful application of these medicaments. There is some evidence that ultraviolet light has a favorable action in these lesions, for in one case a spontaneous cure was obtained after many months by this method. A number of cases have apparently been benefited and have healed following the use of maggot therapy,^{3, 4} but in one of our cases in which this was tried, it had no appreciable beneficial result, and the maggots nearly drove the patient wild by their activity.*

We have demonstrated again and again, however, that the careful application of zinc peroxide will almost invariably effectively halt the spread of this infection. There are certain essential conditions for the success of this treatment. First, the zinc peroxide must be an effective preparation. In other words, it must have certain physical properties which will provide the necessary environment to inhibit or destroy the causative organisms. These physical properties may be determined by a simple laboratory test. Zinc peroxide is a finely divided white powder having the consistency of chalk or talcum. It must be heated at 130° to 140° C. for one to four hours to sterilize it and mobilize the oxygen. When it is suspended in ten parts by weight of distilled water it sediments rapidly, leaving a clear supernatant fluid. In the course of an hour bubbles of oxygen begin to form in the sediment, which after twenty-four hours becomes flocculent and curdy with the evolution of a considerable quantity of oxygen gas. Five grams in 50 c.c. of distilled water should liberate 10 to 20 c.c. of oxygen in twenty-four hours. Further confirmation of the effectiveness of the preparation may be had by determining the amount of soluble oxygen produced in the supernatant fluid and by testing the antiseptic powers of the suspension against the organism which has been recovered from the lesion in any given case.

The next requirement for the successful use of zinc peroxide is that every part of the infected surface must be made available for contact with this medicine. If this is not possible without operation, undermined flaps and sinuses should be widely opened and all of the infected surfaces should be flooded with a creamy suspension of the

*In several cases which have come under observation since submission of this paper, we have used the newly advocated antistreptococcal dye prontosil or its active principle sulphonamide. Although it is not as active against microaerophilic organisms as against ordinary streptococcus, there is evidence that it may be used in conjunction with zinc peroxide to prevent a spread or recurrence, particularly in those areas which cannot be adequately reached by the zinc peroxide.

powder in distilled water, using approximately equal parts of water and powder. This should not be put on in the form of a paste but in the form of a thick cream, which is able to run to all parts of the wound. The wound should then be packed with fine-meshed gauze or silk ribbon soaked in the same material and sealed with vaseline or zinc oxide gauze to prevent evaporation, drying, crumbling, or caking. This dressing should be removed, the old material and exudate thoroughly washed off with distilled water or saline, and a fresh dressing applied every twenty-four hours. As soon as the undermined flaps have sealed down and new skin has begun to grow in from the margins, the ulcer may be covered with skin grafts of the Reverdin type. These should be held in place with a single layer of coarse-meshed gauze, sealed to the skin margins with collodion, then a dressing of fine-meshed gauze soaked in saline should be applied and sealed over with vaseline gauze to prevent evaporation. After twenty-four hours the saline compresses should be removed, and a thin suspension of zinc peroxide should be applied over the coarse-meshed gauze and sealed in turn with an impermeable covering. Forty-eight hours after the skin graft, the coarse-meshed gauze may be carefully removed, leaving the grafts well supplied with blood. These should all be pink and firmly adherent at that time. Thereafter the grafted area may be flooded daily in the same way as the rest of the wound, with a creamy suspension of zinc peroxide.

If possible, frequent cultures should be taken of various parts of the wound to indicate the presence or absence of the infecting organism. Although clinical evidence of diminished activity is readily recognized, the cultures not only confirm the clinical manifestations but also very often precede them. Under the zinc peroxide treatment, if contact is obtained with every part of the wound surface, the organism rapidly loses its anaerobic predilections, grows as readily aerobically as anaerobically, and very soon loses its hemolytic property on blood agar plates, the colonies taking on a green tinge. Eventually these green progeny of the original organism become permanently green, and although they may resist the bactericidal action of zinc peroxide in the test tube, the wound continues to heal in their presence. The surgeon in charge of the case must be constantly on the lookout for any evidence of reactivity due to failure to obtain contact with some small area difficult to reach. Careful application of the zinc peroxide in such areas will obviate the formation of an active focus, but there is always a possibility of these forming until the area is completely covered with epithelium, and occasionally such areas of reactivity have to be radically excised before they can be completely controlled. When the hemolytic organisms have completely disappeared and the surface is

flat, final epithelialization of the wound may be hastened by the application of an ointment containing 2 per cent oxyquinoline in 5 per cent scarlet red.

This disease should not be confused as Holman³ has done with the gangrenous type of chronic ulceration which we have previously described in several papers.⁵⁻⁷ That disease is caused by the synergistic action of a *nonhemolytic* microaerophilic streptococcus which may be found in pure culture in the spreading margin of the lesion, and a *Staphylococcus aureus* which is associated with it in the gangrenous zone which is always present around a part or all of the periphery of the ulcer. That lesion is more superficial. There is no undermining of the skin margins and no sinus formation. The zone of gangrene is surrounded by a raised purple zone, and this in turn by a brilliant zone of erythema.

We have presented herewith ten cases of chronic, undermining, burrowing ulcer caused by a microaerophilic, hemolytic streptococcus, and from these cases have presented a composite picture of this disease. We have outlined the method of treatment with zinc peroxide, which seems to be the only effective method yet devised for stopping the infection and initiating rapid healing of these ulcers. We have emphasized the importance not only of using a preparation of this chemical, which has certain necessary physical properties which can be tested in any laboratory, but also the necessity for meticulous care in the correct application of the medication, and we have indicated other steps in the technic which favor the eventual healing of the wound. An urgent plea is made for the early recognition of these cases and also for the establishment of adequate facilities in every hospital for anaerobic bacteriologic service.

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COMPLETE COMPOUND COMMINUTED FRACTURE- DISLOCATION OF THE ASTRAGALUS

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COMPLETE dislocation, simple or compound, of the astragalus is a rare injury. A compound comminuted fracture-dislocation of this bone is seldom seen. The astragalus may be dislocated in any one of five positions: medial, lateral, anterior, posterior, or rotary. The mechanism of the dislocation is little understood, except that it takes severe violence to produce a complete dislocation.

At one time the treatment advocated for this type of injury was excision of the astragalus, as it was thought that after its complete dislocation the circulation was so severely impaired that necrosis would follow any type of reduction.

The circulation of the astragalus has been little understood, as very little investigative work has been done along this line; but Sneed¹ has presented an excellent study of the blood supply of the astragalus. It is one of the few studies of its kind to be found in the literature.

In the simple dislocations of the astragalus there is a marked deformity. The dislocated bone may be seen and palpated under the tightly stretched skin. The malleoli and os calcis are usually uninjured; the malleoli generally rest on the os calcis. Radiographs should be taken to confirm the diagnosis.

Simple dislocations should be reduced immediately by closed reduction under a general anesthetic. It may sometimes be necessary to use a pin through the os calcis in order to obtain the proper amount of traction. While traction and countertraction are maintained, the astragalus is forced back into its normal position by direct pressure. If this is impossible, open reduction should be employed.

Sneed¹ reported a most interesting case, in which open reduction was necessary, the peroneal tendons had to be cut, and the astragalus was completely removed, after which the bone was replaced. The result was excellent, and there was no change due to any interference with the blood supply.

Compound dislocations occur occasionally and should be treated according to the principles of treatment of any compound dislocation. The bone may be fractured, but even in this instance, notwithstanding the fact that it is comminuted, reapposition of the fragments and replacement of the bone should be done if possible. The following case will illustrate recovery from this type of injury.

CASE REPORT

D. L., colored male, aged fifty-four years, was admitted to the Employees' Hospital, July 29, 1935, shortly after he had sustained a severe injury to his right ankle while working in a coal mine. The patient stated upon admission to the hospital that he had been struck on the right shoulder by a large rock, which fell from above. This knocked him down, and another rock fell on his right foot and ankle, causing a serious open wound in the region of his ankle.

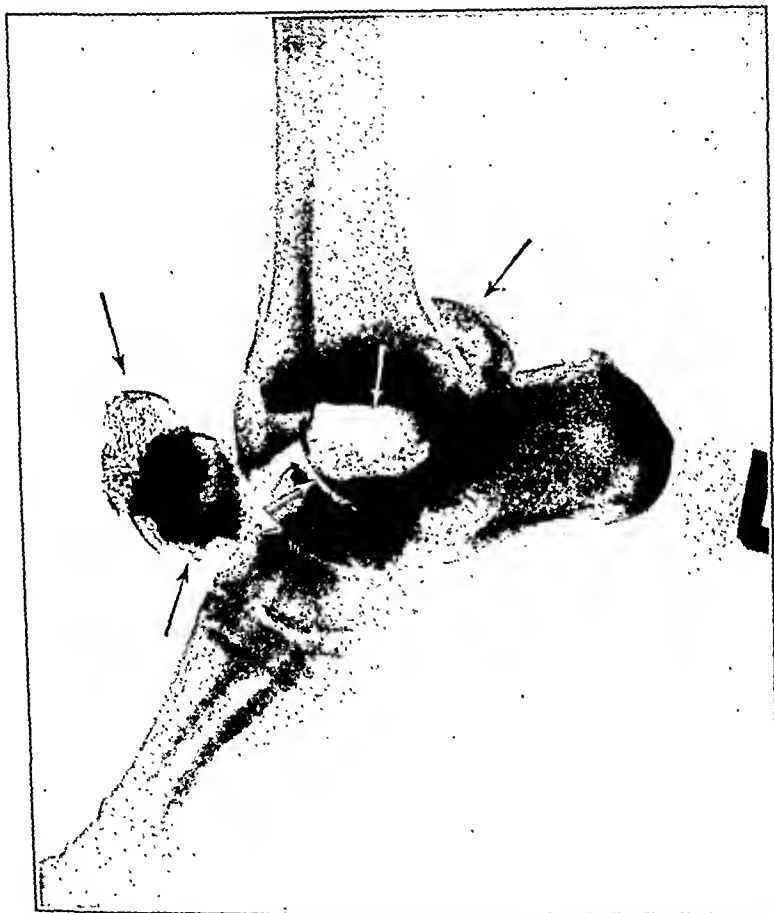


Fig. 1.—A compound comminuted fracture-dislocation of the right astragalus, fragments being displaced, anteriorly, posteriorly, and laterally.

Examination on admission to the hospital revealed a well-developed and nourished negro male. He was in severe pain, complaining of discomfort in the right shoulder, chest, and ankle. Patient was moderately shocked. Examination of the right ankle revealed an extensive compound comminuted fracture-dislocation of the astragalus. It was completely severed from all its attachments except for a few fibers of the external lateral ligament of the ankle. There was a laceration on the outer aspect of the ankle, about three inches in length, which opened up the entire ankle joint, and through which the astragalus protruded. The entire wound was contaminated with particles of dirt, rock, and coal. Active hemorrhage was present.

A roentgenogram revealed a comminuted fracture-dislocation of the astragalus (Fig. 1). The astragalar fragments were displaced outwardly, anteriorly, and posteriorly. Following the treatment for shock, the patient was taken to the operating room, and under general anesthetic, the wound was thoroughly cleansed and débrided. The astragalus was so severely comminuted, being torn almost entirely from its ligaments, that a complete astragalectomy was at first considered the only possible treatment. After the wound was cleansed and débrided, however, attempts

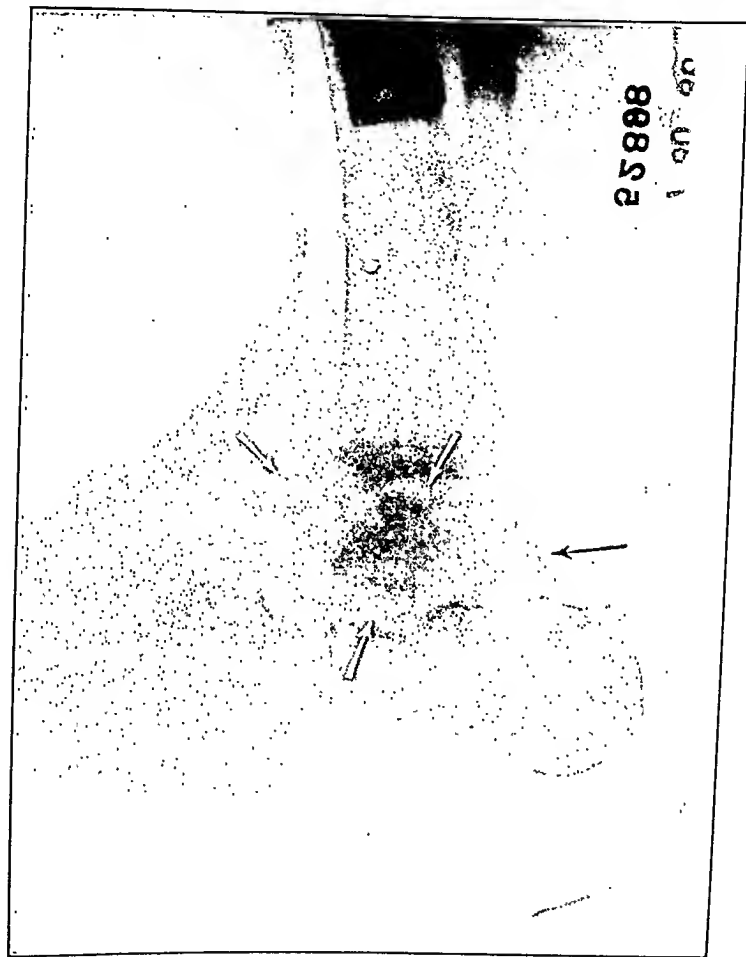


Fig. 2.—Position of the astragalus following reduction. Because of the marked comminution, it was impossible to replace all fragments in perfect position.

were made to get the fragments of the astragalus into reapposition and replace them in their original site in the tibiofibular mortise. This was done with difficulty, but it was decided that the wound would be closed without performing an astragalectomy, even though there would be considerable danger of necrosis of the astragalus due to a possible loss of circulation. The wound was closed without drainage. A circular plaster cast was applied to the foot and leg above the knee, with the knee in slight flexion. A window was cut in the cast for observation and care of the wound. Healing occurred by primary intention.

Roentgenogram taken immediately after reduction of the dislocation showed that there was not an accurate anatomical reduction (Fig. 2), but due to the severe comminution, it was thought this position could hardly be improved upon.

The cast was removed after a month, when the wound had healed and the swelling had practically subsided. Another cast was applied from the base of the toes to the middle of the thigh, and the patient was allowed to be out of bed with crutches. This cast was removed in two weeks, and a light cast was applied to the foot and leg below the knee, which was removed two weeks later or two months after injury.

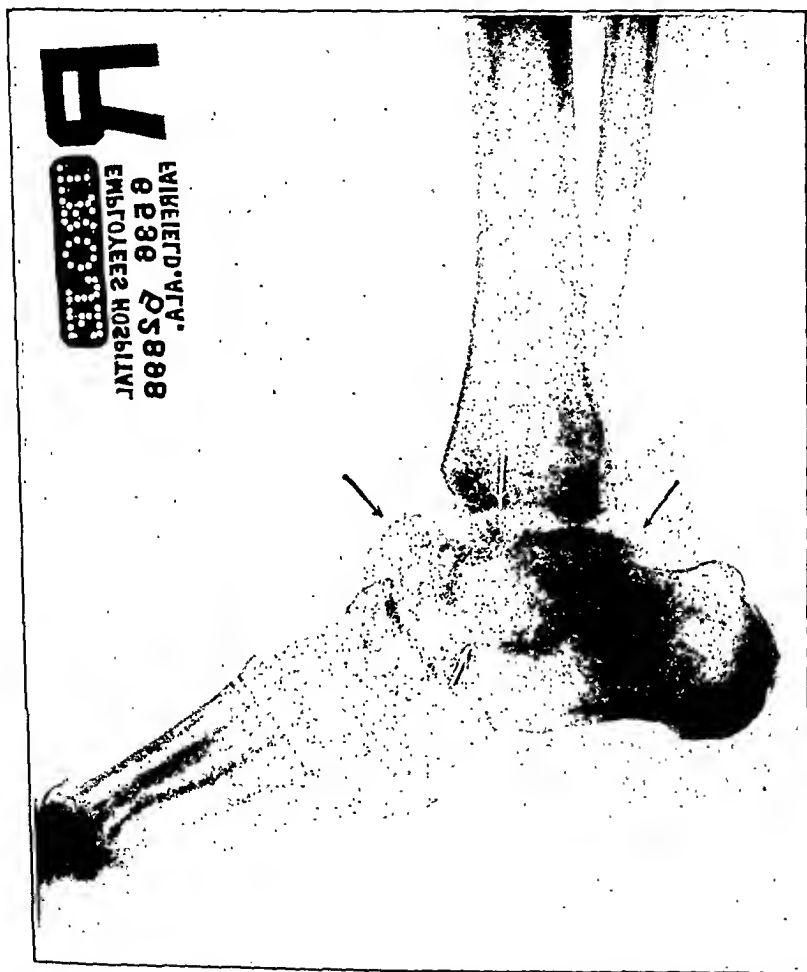


Fig. 3.—Roentgenogram, taken ten months after injury, shows no necrosis. Even though the position of fragments are not perfect, the weight-bearing surface and alignment are good, much better than if no astragalus was present.

Weight-bearing, with the aid of crutches and an ankle and leg brace, was started three months after injury. The crutches were discarded a month later. The ankle continued to swell considerably on active weight-bearing, but this slowly subsided, and the patient could walk without pain or discomfort.

Roentgenogram (Fig. 3) taken ten months after injury revealed no necrosis of the astragalus.

The patient was last seen on May 22, 1936, for follow-up. At that time there was still slight enlargement of the right ankle joint, with only moderate limitation of motion. The patient walked without ankle or leg supports, and even though there was a slight limp, he was free of pain (Fig. 4A and B).



Fig. 4A.



Fig. 4B.

Fig. 4, A and B.—Photographs showing the condition of the foot and ankle ten months after injury.

COMMENT

The results obtained in this case, although accurate anatomical reduction was impossible, seem to justify replacement of the astragalus, even when there is a compound comminuted fracture-dislocation of the bone. It is interesting to note that in this case there was evidently serious circulatory disturbance in the bone which reestablished itself without the occurrence of any necrosis.

SUMMARY AND DISCUSSION

1. Complete dislocations of the astragalus are unusual. Compound comminuted fracture-dislocations of the astragalus seldom occur.
2. Immediate closed reduction is the treatment of choice in simple dislocations and is usually successful.
3. Open reduction is indicated at once if the closed method is unsuccessful.
4. Compound dislocations, with or without fractures, should be treated by cleansing and débridement of the wound and a replacement of the dislocated bone.
5. The circulation is usually reestablished in the astragalus, even though it is severed from all connections.

6. A case of compound comminuted fracture-dislocation of the astragalus is reported in which reduction was performed without the occurrence of necrosis, and the functional result was satisfactory.

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THE OPERATIVE TREATMENT OF HYDRONEPHROSIS DUE TO OBSTRUCTION AT THE URETERO- PELVIC JUNCTION*

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HYDRONEPHROSIS due to obstructive lesions at the junction between the renal pelvis and the ureter is a relatively common condition, 25 cases having been seen at the University Hospital since April, 1930. Its frequency is probably due to the variety of lesions which may produce it. The causative lesions are best classified as follows:

1. Fibrosis in the wall of the ureter (stricture).
2. Fibrosis about the ureter (compression, angulation).
3. Accessory vessels to the lower pole of the kidney, if accompanied by periureteral adhesions or by nephroptosis.
4. Neurogenic dysfunction of the pelvis and ureter.
5. High (nondependent) attachment of the ureter to the renal pelvis.

THE MECHANISM OF OBSTRUCTION

The mechanism by which these conditions produce hydronephrosis may vary considerably. Fibrosis, either inflammatory or traumatic, may produce a ureteral stricture (Fig. 1, *a*) or, by infiltrating the wall of the ureter, render it inelastic and so impede peristalsis as to cause stasis, without actually compromising the lumen of the ureter. Periureteral fibrosis is probably not important unless it also invades the wall of the ureter or kinks it very sharply while binding it to adjacent structures, such as the renal pelvis, the posterior abdominal wall, or accessory renal vessels (Fig. 1, *b*). Kinking of the ureter without infiltration or fixation does not cause obstruction.

Whether accessory renal vessels unaccompanied by any other abnormality may interfere with drainage of the renal pelvis is open to grave doubt, although Quinby claims that the continual pounding of an artery against the ureter may disturb peristalsis sufficiently to produce hydronephrosis. Fibrosis about the ureter and accessory vessel (Fig. 1, *b* and *c*), or an associated ptosis of the kidney, may undoubtedly lead to compression of the junction by the vessel.

In a few cases of hydronephrosis without dilatation of the ureter, it is necessary, because of the absence of any demonstrable pathologic state, to assume a defect, presumably neurogenic, in the activity of the pelvic and ureteral muscle. This may take the form of a spasm of the circular

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muscle at the junction, or of peristalsis too feeble to empty the pelvis. Many of these cases are probably actually due to an unrecognized mechanical obstruction.

High insertion of the ureter or, more properly, high attachment of the ureter to the renal pelvis, is often mentioned as a cause of hydronephrosis, the latter being attributed by Fenger to the formation between the pelvis and ureter of a valve which is closed by a rise in the intrapelvic pressure (Fig. 1, *b* and *c*). More probably the high position of the ureteropelvic junction is secondary to the dilatation of the pelvis incident to one of the causes already enumerated.

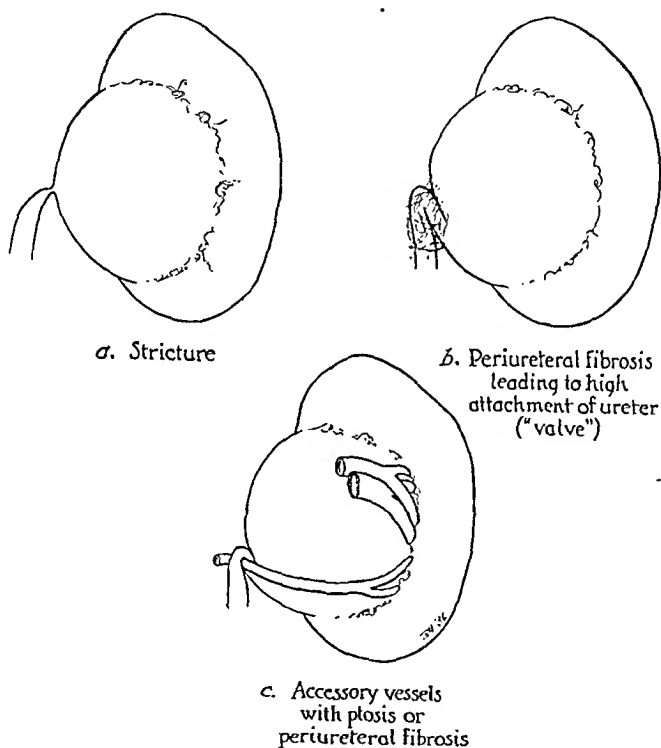


Fig. 1.—The chief lesions which produce obstruction at the ureteropelvic junction.

THE CLINICAL PICTURE

The clinical appearance of these conditions is variable, and may consist of an occasional vague pain in the flank, intermittent or continuous renal pain or colic, attacks of recurrent acute infection, chronic pyuria, or of reflex gastrointestinal disturbances without pain. The classical picture of Dietl's crisis (polyuria following colic), is rarely seen. It is worth remembering that the urine is often normal, and that, in an occasional case, the symptoms are all, or nearly all, gastrointestinal in character.

There are no constant physical findings, although the affected kidney may be palpable during attacks. Fever is usually dependent upon in-

fection, and the picture of recurrent acute pyelonephritis in young people is that most often seen.

The diagnosis is dependent upon pyelography. Usually the excretory urogram suffices, but a retrograde pyeloureterogram is often required to demonstrate that the ureter below the obstruction is normal, since the latter often prevents filling of the ureter during excretory urography. The pyelogram ordinarily shows a hydronephrosis, with a ureter of normal caliber. Certain other changes are suggestive when present; namely, a bifid renal pelvis, a squared pelvic outline, and a high attachment of the ureter to the renal pelvis.

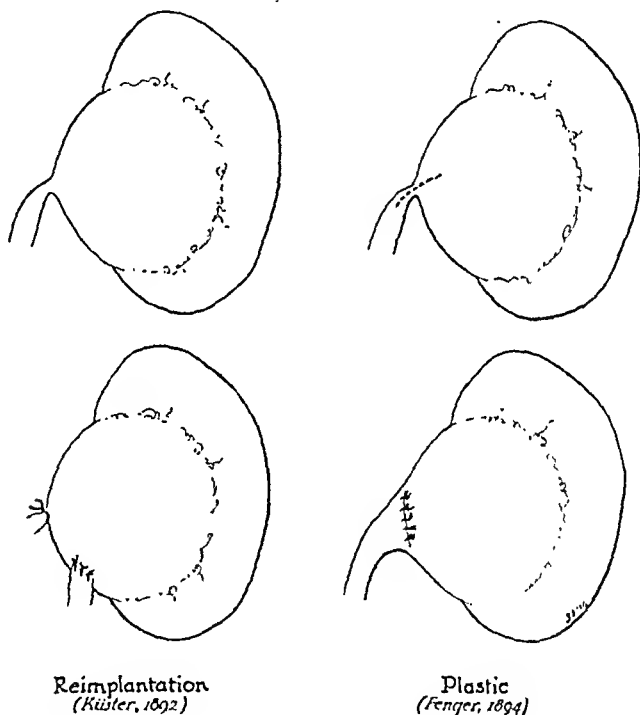


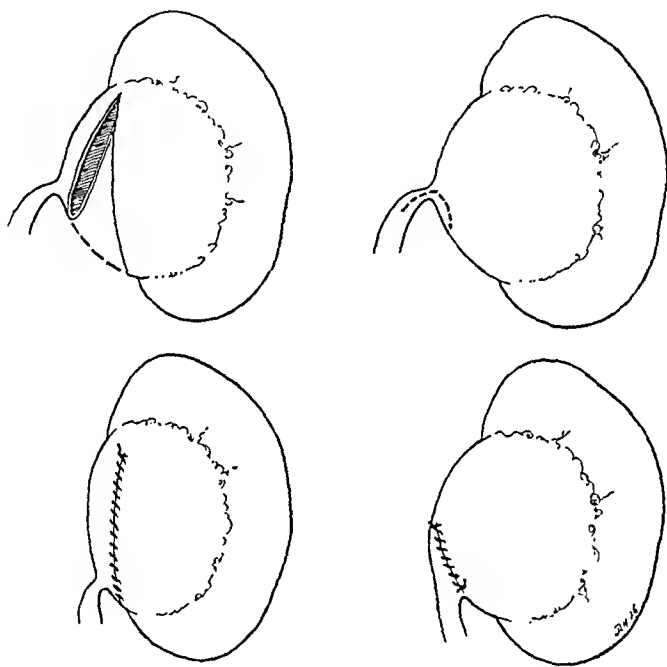
Fig. 2A.—The operations for obstruction at the ureteropelvic junction.

TREATMENT

Unfortunately, the majority of these cases are treated by nephrectomy (fifteen cases in this series). There are several reasons for this. The patient may fail to seek advice until the kidney is too completely disorganized to permit saving it, although, in my experience, a kidney containing as little as one-third of the normal amount of parenchyma may be reclaimed. Conservative operations upon such kidneys are amply justified by their results, and by repeated experimental observations showing that animals may survive when two-thirds of their total renal parenchyma has been removed (and seven-eighths if small portions of

the kidney are removed in stages, allowing hypertrophy to follow the removal of each bit before proceeding further).

Many surgeons are unaware of the possibilities of conservative operations upon the kidney, while others oppose them except in bilateral disease, agreeing with Hinman that, if the kidney opposite to the lesion has undergone hypertrophy, the affected one will atrophy in spite of attempts to save it. Hinman argues that the presence of the hypertrophied normal kidney prevents the stimulus to function from reaching the damaged organ. While this view is borne out by Hinman's experiments, it has been repeatedly disproved in practice, particularly by



Resection of Pelvis
(Gayet, 1912)

Lateral Anastomosis
(Von Lichtenberg)

Fig. 2B.—Operations for obstruction at the ureteropelvic junction.

the experiences of Bazy, Legueu, von Lichtenberg, and Wildbolz. They have reported instances in which the kidney functioned normally or was normal anatomically fifteen to twenty-four years after conservative operations for hydronephrosis due to obstruction at the outlet of the renal pelvis.

With the possible exception of an occasional stricture at the ureteropelvic junction, nonoperative measures are of decidedly limited value. They consist of the administration of urinary antiseptics, of ureteral dilatation, and of lavage of the renal pelvis. Recurrence is the rule after such treatment, and the condition is often aggravated by it.

All forms of operative therapy (Figs. 2 and 3) have as their object the relief of stasis in the renal pelvis, with reduction in the size of the pelvis as a secondary and less important consideration, although the latter is desirable if the pelvis is very large, in which case its size renders peristalsis ineffective.

The first deliberate conservative operation for obstruction at the ureteropelvic junction was probably that of Küster (1892), who, in the presence of a hydronephrosis due to a stricture at the junction, ligated the ureter, cut it off below the stricture, and reimplanted it into the dependent portion of the pelvis. The patient recovered. The method is still rather widely used, notably by von Lichtenberg, Wildbolz, and

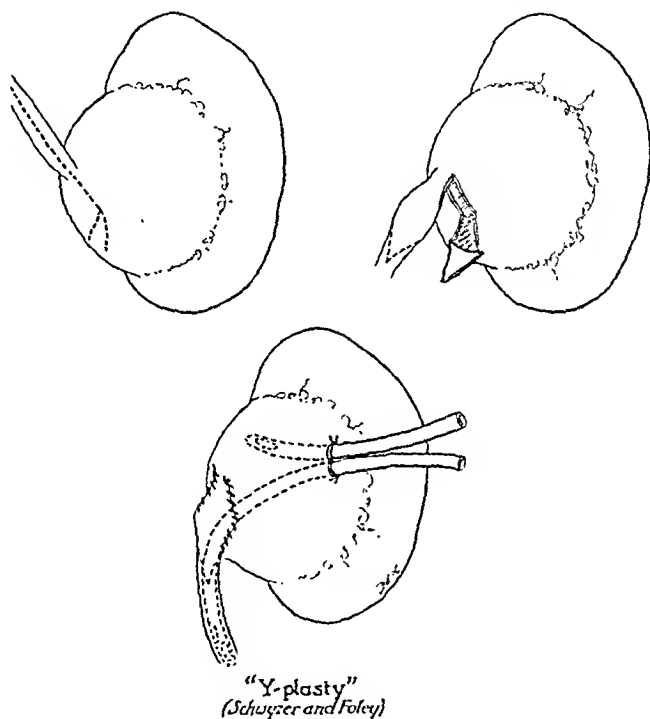


Fig. 3.—Y-plasty (Foley).

Quinby. The possibility of a recurrent stricture at the point of anastomosis constitutes a theoretical objection to the operation. Another defect in this method is that it interrupts the continuity of the ureter with the pelvis, which is undesirable if it be true that peristaltic waves originate in the pelvis and pass down the ureter.

Next in point of time is the operation of Fenger (1894) who incised the stricture longitudinally and closed it transversely. This operation has many advocates, but Herbst and Polkey have shown experimentally that it produces a kink in the ureter opposite the suture line, and that this kink may itself produce obstruction and so defeat the purpose of the operation.

When the ureter is angulated and plastered against the pelvis, von Lichtenberg has made a lateral anastomosis between them, based on the Finney pyloroplasty. The method has been used successfully by Walters. It has the objectionable feature that the spur formed between the ureter and pelvis may become edematous and cause obstruction.

Gayet has advocated resection of the redundant pelvis in such a manner as to place the ureter in a dependent position, but this operation fails to correct the obstruction, which Gayet assumed to be due to the high attachment of the ureter. Young has attempted to overcome this fault by adding Fenger's plastic operation, the objections to which have already been noted.

When the obstructing force appears to be an anomalous blood vessel, Hellström resects the excess pelvis and sutures the vessels to the pelvic wall above its connection to the ureter.

In a similar situation Patch severs the pelvis transversely above the level of the anomalous vessels, and resutures it on the other side of them.

I do not believe that anomalous blood vessels cause hydronephrosis unless the ureter is angulated and fixed around them by periureteral fibrosis or nephroptosis, and I prefer, in such cases, to widen the ureteropelvic junction on the assumption that spasm or anatomic obstruction exists. Moreover, ligation of a renal vessel invariably produces infarction of the area supplied by it. While this is usually a silent process which destroys only a small portion of the kidney, it may become infected and necessitate nephrectomy.

Alleman has advocated longitudinal incision of the circular muscle at the junction down to, but not through, the mucosa for those cases seemingly due to spasm, as in the Fredet-Rammstedt operation for pyloric stenosis, but this method, like divulsion of the junction with a bougie at operation, seems to invite recurrence.

To my mind the most satisfactory method of dealing with these cases is the operation devised by Schwyzer and improved by Foley (Fig. 3).

Schwyzer divided the posterior surface of the upper inch of the ureter by a longitudinal incision, which he then prolonged upward onto the pelvis in the form of a V. The apex of the triangular flap of pelvic wall thus outlined was pulled down to the lower end of the incision in the ureter, and the incision closed as a V, thus widening the junction without interrupting its continuity or angulating it.

Foley has moved the longitudinal incision in the ureter onto its lateral aspect, and extended it above the ureteropelvic junction. One limb of the V incision in the pelvis is placed on its anterior, and the other on its posterior surface, so that suture places the junction in a dependent position. The V-shaped closure is made by carefully placed interrupted sutures of 0000 chromic catgut on atraumatic needles. These sutures include only the muscularis and adventitia, and do not penetrate the mucosa. A small catheter is placed through the anastomosis and brought out through the posterior surface of the pelvis. Openings into the

catheter are so placed that it drains the pelvis, diverts the urine, and splints the anastomosis during healing. More recently Foley has employed an additional catheter as a pyelostomy. Three painful experiences caused by slipping of such tubes, with consequent extravasation of urine into the wound, have led me to supplement the diversion of the urine by inserting a No. 22 Malecot catheter into a lower calyx of the kidney as a nephrostomy.

Foley has placed considerable emphasis on the importance of nephropexy, but I have purposely avoided high fixation of the kidney. I have simply held it high enough to avoid kinking of the ureter by suturing the perirenal fat and peritoneum loosely beneath the lower pole of the kidney, somewhat in the manner of Deming. The results have convinced me that a painstaking nephropexy merely adds unnecessarily to the length of the operation.

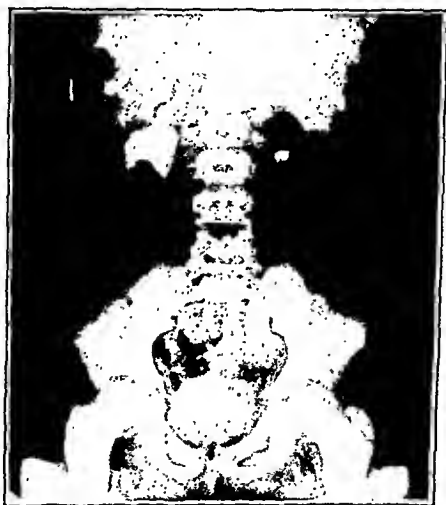


Fig. 4.—Hydronephrosis before Y-plasty (Case 1).

THE RESULTS OF OPERATION

I have performed this operation nine times, supplementing it twice by excision of redundant pelvic wall, and once by resection of the lower pole of the kidney, together with a contained stone which could not be located. In an additional case, Küster's division of the ureter with reimplantation into the dependent portion of the pelvis was done, and supplemented by excision of most of the wall of the pelvis.

The first operation was done in November, 1932, the last in June, 1936. The patients ranged in age from ten to fifty-seven years. There were no deaths. Several presented postoperative complications, but all have recovered and are entirely symptom-free at the present time, with the exception of one patient who required nephrectomy ten weeks after operation because of persisting obstruction and extravasation of urine. All patients operated upon more than six months ago have had pyelo-

grams made at least six months, and in one instance three years, after operation, which show functioning kidneys secreting clear, uninfected urine. In all but one there has been a notable reduction in the size of the pelvis since operation; in the one in which the size of the pelvis has remained unchanged (Fig. 4) an infection of four years' standing has disappeared, together with all symptoms.

COMPLICATIONS

Complications of varying severity followed operation in 5 cases.

In the first of these, a thirteen-year-old boy, an accessory vessel to the lower pole was divided, a large portion of the pelvis was resected, and the ureter was reimplanted into a dependent position. A temperature of



Fig. 5.—Hydronephrosis (A) before and (B) after Y-plasty and partial resection of pelvis (Case 4).

105° F., without subjective or objective findings, appeared on the third day and lasted three days, apparently from infarction of the lower pole of the kidney. Thereafter recovery was normal. One and one-half years later the patient was well, the preoperative infection had disappeared, and the kidney functioned well as judged by excretory urography, considering that only one-third of the normal amount of renal parenchyma was present at operation.

In the second, a man twenty-five years old, a pseudoleucemia followed operation, the white blood count rising to 47,000 and the hemoglobin falling from 90 to 40 without evidence of hemorrhage. This reaction subsided uneventfully following transfusion. A year later the urine from the right kidney was clear, and retrograde pyelography disclosed a very marked reduction in the size of the renal pelvis.

In the third instance, ecchymosis in the unoperated kidney occurred when the patient got up after operation (resection of the lower pole of the right kidney with an enclosed stone, Y-plasty); a stone was subsequently passed from the left side. Retrograde pyelography eighteen months after operation disclosed a considerable reduction in the size of the kidney, which secreted clear urine.

In the fourth, a woman of thirty-five, urine was discharged through the incision for ten weeks after operation; at cystoscopy a piece of necrotic tissue was seen protruding from the ureteral meatus. Closure of the fistula followed extraction of the necrotic tissue and ureteral dilatation.

In the fifth patient, a woman of thirty, operation was a failure due to a technical blunder. She had a stricture at the ureteropelvic junction, another in the upper third of the ureter, and a third at the upper



A.



B.

FIG. 6.—Hydronephrosis (A) before and (B) after Y-plasty and resection of the lower pole of the kidney (Case 2).

margin of the sacrum. Repeated ureteral dilatations having proved fruitless, Y-plasties were done on the upper two strictures and a nephrostomy was made with a plain catheter, the intention being to repair the third stricture later. An extravasation of urine followed slipping of the tube, and nephrectomy had to be done some months later for a renal fistula.

SUMMARY AND CONCLUSIONS

1. Obstruction at the ureteropelvic junction may be due to stricture, to compression by scar tissue, to anomalous vessels to the lower pole of the kidney complicated by periureteral adhesions or by nephroptosis, and to disturbances of the nervous mechanism of the ureteropelvic junction, leading to ineffective peristalsis or to spasm.

2. Nonoperative treatment is of very limited value, its effects being purely palliative.

3. The various operations designed to correct obstruction at the ureteropelvic junction have been described.

4. The Y-plasty of Schwyzer and Foley is, in my opinion, the method of choice, in that it widens the ureteropelvic junction without interrupting its continuity or producing angulation or spurs.

5. Ten cases are reported, in 9 of which Y-plasty was done. In 2 of these, redundant pelvic wall was also resected, and in 1 the lower pole of the kidney was removed, together with a contained stone.

6. In the tenth case, the ureter was divided and reimplanted into a dependent position, and the redundant pelvis was resected.

7. In one case, an infected infarct followed ligation of vessels to the lower pole but did not impair the end-result.

8. There was no mortality. All patients except one have been relieved of all symptoms, and all infections have subsided.

9. Nephrectomy was later required in one case because of persisting obstruction with urinary extravasation.

10. There is a wide field for this type of operation.

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In the third instance, colic in the unoperated kidney occurred when the patient got up after operation (resection of the lower pole of the right kidney with an enclosed stone, Y-plasty); a stone was subsequently passed from the left side. Retrograde pyelography eighteen months after operation disclosed a considerable reduction in the size of the kidney, which secreted clear urine.

In the fourth, a woman of thirty-five, urine was discharged through the incision for ten weeks after operation; at cystoscopy a piece of necrotic tissue was seen protruding from the ureteral meatus. Closure of the fistula followed extraction of the necrotic tissue and ureteral dilatation.

In the fifth patient, a woman of thirty, operation was a failure due to a technical blunder. She had a stricture at the ureteropelvic junction, another in the upper third of the ureter, and a third at the upper

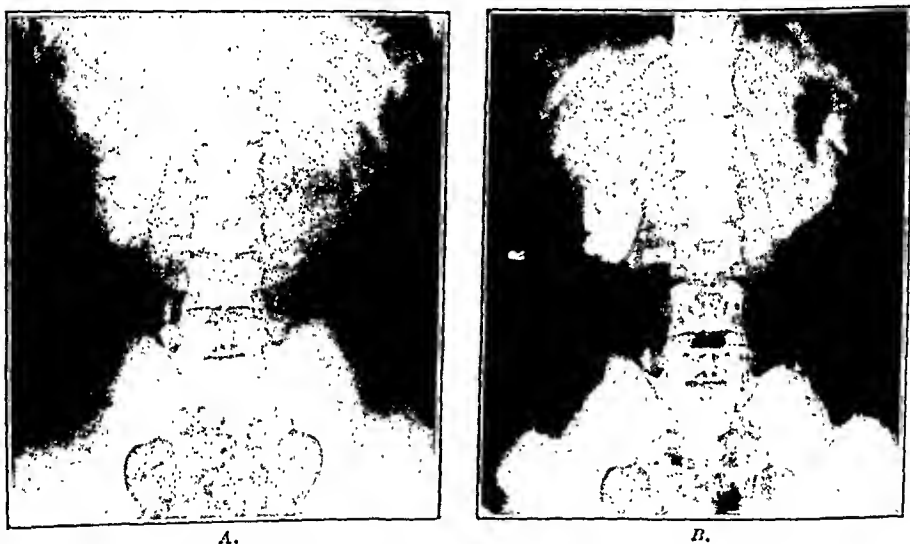


FIG. 6.—Hydronephrosis (A) before and (B) after Y-plasty and resection of the lower pole of the kidney (Case 3).

margin of the sacrum. Repeated ureteral dilatations having proved fruitless, Y-plastics were done on the upper two strictures and a nephrostomy was made with a plain catheter, the intention being to repair the third stricture later. An extravasation of urine followed slipping of the tube, and nephrectomy had to be done some months later for a renal fistula.

SUMMARY AND CONCLUSIONS

1. Obstruction at the ureteropelvic junction may be due to stricture, to compression by scar tissue, to anomalous vessels to the lower pole of the kidney complicated by periureteral adhesions or by nephroptosis, and to disturbances of the nervous mechanism of the ureteropelvic junction, leading to ineffective peristalsis or to spasm.

renal venous blood for analysis was obtained from the cannula, and the arterial blood was taken from the femoral artery. Heparin was used as the anticoagulant.

A preliminary operation was performed under general anesthesia approximately one week before carrying out the control determinations on the renal blood flow and oxygen consumption. At the time of this operation, all visible veins which entered the renals or the inferior vena for a distance of 3 cm. above and below the level of the renals were ligated. The one exception was the right adrenal vein which was occluded distal to its entrance into the gland, but which was free to convey blood from the adrenal to the vena cava. The second purpose of the operation was to locate the position of the entrances of the renal veins with respect to a scar on the anterior abdominal wall, in order that the cannula could be passed subsequently to the correct point.

The control determinations were performed approximately one week after the preliminary operation. After a second interval of about seven days, each ureter was occluded by a heavy tape ligature at a distance of several centimeters from the entrance into the bladder. The ureter was doubly ligated with silk between the tape and the bladder, and it was divided between the ligatures. In one experiment, obstruction of the urinary tract was produced by occluding the base of the bladder with a heavy ligature of tape. The animals were observed carefully, and further measurements of the renal flow were made when they began to show signs of uremia. This was usually on the third or fourth day following the occlusion of the ureters.

RESULTS

The data of eight consecutive experiments are given in Table I. Eleven experiments were performed prior to the eight which are described in the table, but the results will not be given in detail for the following reasons: In some instances, the ligatures had cut through one or both ureters, and urine was present in the peritoneal cavity. In several experiments, the condition of the animal was so poor that shock undoubtedly was complicating the observation. In addition, the animals became quite anemic in some of the earlier experiments, and a proper evaluation of the results was difficult. There is one striking point, however, in the results of these eleven studies as well as in those described in the table, and that is the fact that the arteriovenous oxygen difference is small in most instances. This applies to the determinations before and after occlusion of the ureter. One additional point deserves comment. It was found in one experiment that the renal blood flow three days following occlusion of the ureters was

THE EFFECTS OF URETERAL OCCLUSION ON THE BLOOD FLOW AND OXYGEN CONSUMPTION OF THE KIDNEYS OF UNANESTHETIZED DOGS

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A METHOD was described recently by Mason, Blalock, and Harrison^{1a, 1b} which enables one to determine directly the flow of blood through the kidneys, and which also permits one to obtain renal venous blood for analysis in unanesthetized dogs. The present publication deals with the results of the application of this method to the study of the circulation through the kidneys following ureteral obstruction.

METHOD

Dogs were employed as experimental animals. They were trained to lie quietly upon the table. No anesthetic was used except for the local injection of novocain over the external jugular vein at the site where a cannula was to be introduced. The animals exhibited no evidence of pain during the course of the experiments.

The principle of the method consists of producing a temporary blockage of the inferior vena cava both above and below the entrances of the renal veins, and diverting the blood during this brief period into a cannula which has been passed into the inferior cava through the external jugular vein. The cannula was 45 cm. in length and was made of brass. The distal end (kidney) was closed, and the proximal end (neck) was patent. The cannula was equipped with two externally expanding balloons, one located at the distal end, and the second 7.5 cm. above it. These could be inflated with air from the proximal end of the cannula through two fine tubes lying in its lumen. Multiple perforations into the lumen of the cannula were present between the balloons. The balloons were inflated only during the time that the blood was allowed to flow from a rubber tube which was attached to the proximal end of the cannula. The level at which the outflow tube was placed has been discussed.² The length of time that was required for the escape of 50 c.c. of blood was determined, the blood being replaced immediately following the measurement. The sample of

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the same as it had been in the control studies. At autopsy it was found that both ureters were draining into the peritoneal cavity as a result of the cutting through of the ligatures.

DISCUSSION

There was a reduction in renal blood flow in each of the eight experiments. The percentage reduction in flow varied from 23 to 66 per cent in the different experiments, the average being 41 per cent. The difference in oxygen content of the arterial and renal venous blood was small in most experiments, both before and after ureteral ligation. In one experiment (No. 31), the arteriovenous difference was high in the control study; and in another experiment (No. 128), it was high following obstruction of the ureters. We doubt the correctness of these results. It has been pointed out previously that the figures for blood flow are probably more nearly correct than those for oxygen consumption. This is due to the fact that oxygen content of renal venous blood is high as compared with that of neighboring structures, and a slight error in collection may make a significant alteration in the figure for oxygen consumption without changing greatly the true value for the renal blood flow.

The hydronephrosis which resulted from the ligation of the ureters was not very marked in any of the studies. The duration of life following such a procedure is not sufficiently long to permit an extensive change to take place. However, the ureters were dilated, the pelves of the kidneys were dilated, and the nonprotein nitrogen content of the blood was elevated. At any rate, we were interested in studying the early effects of acute obstruction and not the chronic stage. It seems almost certain that the renal blood flow would be reduced greatly when marked hydronephrosis with thinning of the cortex takes place.

Three of the eight animals developed hypertension following obstruction of the ureters. Hartwich,³ and Mason, Rainey, Resnik, Minot, Pilcher, and Harrison⁴ similarly reported a rise in blood pressure in some animals following partial obstruction of renal arteries,⁵ and since the renal blood flow is diminished by ureteral obstruction, it seems that the same mechanism may be responsible for the rise in blood pressure following both of these experimental procedures.

The experiments of Hinman and his associates⁶ would lead one to suspect that the renal blood flow is diminished in hydronephrosis. The arteries of the kidneys were injected with opaque material after varying degrees of hydronephrosis had been produced. They found that pelvic distention foreshortens and crinkles the interlobular and arteriole rectae vessels and stretches and lengthens the interlobars and arcuates.

THE CAUSE OF DEATH IN LIVER PERITONITIS
BLOOD CHEMISTRY FINDINGS IN DOGS SUBJECTED TO INTRAPERITONEAL
IMPLANTATION OF FRESH, GROUND, ADULT DOG LIVER
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Research Fellowship)

THE early experiments of Mason, Davidson, Matthew and Rastello¹ upon the toxic effect of intraperitoneal autolysis of dog liver, have stimulated numerous other investigations of the problem. Ellis and Dragstedt,² Andrews, Rewbridge and Hrdina,³ and Dvorak⁴ have shown that associated with autolysis of liver in vivo, there is an abundant growth of bacteria normally found in livers of adult dogs. At the present time there is considerable difference of opinion as to the pathogenic nature of these bacteria and the rôle they play in the early death of dogs following intraperitoneal injection of various preparations of liver tissue and bile salts. Ellis and Dragstedt² and Dvorak⁴ concluded that bacterial peritonitis is the causative factor in the early death of the animals. Andrews, Rewbridge and Hrdina³ stated that the organism is Welch's bacillus and that the rapid death of the animal is explained by this overwhelming toxemia. Furthermore, they were of the opinion that this organism lies dormant in the tissues of the dog and can be stimulated to produce a fatal infection by the intraperitoneal autolysis of sterile liver and bile salts.

We have found that the bacteria in adult dog liver usually consist of varying strains of both aerobic and anaerobic organisms. In every instance one of the organisms has been a large, anaerobic, sporulating bacillus which stains positive by Gram's method. In our studies⁵ this bacterium produced no exotoxin, and was not identical with the Welch bacillus in either morphology or cultural characteristics. In a previous report,⁶ we have shown that fresh liver sterilized by autoclaving does not cause death in dogs when injected intraperitoneally in 100 gram amounts. When, however, the liver is incubated for twenty-four hours or longer and is then sterilized by autoclaving, the intraperitoneal injection of 100 grams causes rapid death of the dog, though the peritoneum remains sterile.

Mason and his coworkers¹ concluded from their early investigations with fresh liver that the rapid death of the animals was due to absorption of toxic substances produced from intraperitoneal autolysis of the

SUMMARY

The blood flow and oxygen consumption of the kidneys of unanesthetized dogs have been determined before and after the production of ureteral obstruction. The findings indicate that early hydronephrosis is associated with a decrease in the renal blood flow, little if any alteration in the arteriovenous oxygen difference, and a decrease in the oxygen consumption.

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THE CAUSE OF DEATH IN LIVER PERITONITIS

BLOOD CHEMISTRY FINDINGS IN DOGS SUBJECTED TO INTRAPERITONEAL IMPLANTATION OF FRESH, GROUND, ADULT DOG LIVER

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(From the Department of Surgery and the Research Division of Indiana University School of Medicine, The Eli Lilly Research Fellowship, Landon Research Fellowship)

THE early experiments of Mason, Davidson, Matthew and Rastello¹ upon the toxic effect of intraperitoneal autolysis of dog liver, have stimulated numerous other investigations of the problem. Ellis and Dragstedt,² Andrews, Rewbridge and Hrdina,³ and Dvorak⁴ have shown that associated with autolysis of liver in vivo, there is an abundant growth of bacteria normally found in livers of adult dogs. At the present time there is considerable difference of opinion as to the pathogenic nature of these bacteria and the rôle they play in the early death of dogs following intraperitoneal injection of various preparations of liver tissue and bile salts. Ellis and Dragstedt² and Dvorak⁴ concluded that bacterial peritonitis is the causative factor in the early death of the animals. Andrews, Rewbridge and Hrdina³ stated that the organism is Welch's bacillus and that the rapid death of the animal is explained by this overwhelming toxemia. Furthermore, they were of the opinion that this organism lies dormant in the tissues of the dog and can be stimulated to produce a fatal infection by the intraperitoneal autolysis of *sterile* liver and bile salts.

We have found that the bacteria in adult dog liver usually consist of varying strains of both aerobic and anaerobic organisms. In every instance one of the organisms has been a large, anaerobic, sporulating bacillus which stains positive by Gram's method. In our studies⁵ this bacterium produced no exotoxin, and was not identical with the Welch bacillus in either morphology or cultural characteristics. In a previous report,⁶ we have shown that fresh liver sterilized by autoclaving does not cause death in dogs when injected intraperitoneally in 100 gram amounts. When, however, the liver is incubated for twenty-four hours or longer and is then sterilized by autoclaving, the intraperitoneal injection of 100 grams causes rapid death of the dog, though the peritoneum remains sterile.

Mason and his coworkers¹ concluded from their early investigations with fresh liver that the rapid death of the animals was due to absorption of toxic substances produced from intraperitoneal autolysis of the

liver material. They pointed out the close correlation between their findings and those reported by Cannon in his investigations on traumatic shock. Later, Mason and Lemon⁷ discussed anhydremia and loss of body fluids intraperitoneally as a contributing cause in the rapid death of the dogs. Recently, Mason and Nau⁸ showed marked degenerative changes in the liver and kidney of dogs subjected to the intraperitoneal introduction of sublethal amounts of fresh liver tissue. They concluded that these changes were caused by the absorption of toxins liberated from autolyzing liver fragments.

In our studies we have made observations which we believe explain many conflicting interpretations of other workers. In all of our investigations, we have been impressed by the marked clinical picture of shock which is associated with the rapid death of dogs when certain preparations of liver are placed intraperitoneally. This report deals primarily with blood chemistry changes in dogs following intraperitoneal injection of *fresh* liver. In an attempt to ascertain whether the presence of bacteria in the peritoneal cavity was a contributing cause in the early death of the animals, smears and cultures were made of peritoneal exudate removed as the dogs were dying.

EXPERIMENTS UPON FRESH, GROUND, ADULT DOG LIVER

All investigators agree that when fresh, adult dog liver, ground or whole, is placed intraperitoneally in the experimental animal, the dog dies usually within twenty-four hours. Furthermore, it is a common belief that the amount of liver introduced has no bearing upon the time the animal survives. The amount of liver introduced has varied with different investigators from 30 to 100 grams.

In all of our experiments the liver was obtained from a sacrificed dog with aseptic surgical technique. As an added precaution against contamination, the liver was plunged into scalding water until the surfaces were coagulated. A small piece of the liver was removed and placed in a good anaerobic culture medium.⁵ The remainder of the liver was ground in a sterile food chopper and placed in sterile Erlenmeyer flasks. The liver material plus an equal volume of sterile normal saline was placed intraperitoneally in the animals a few moments after it was removed from the sacrificed dog. The animals receiving the liver were given no food for twenty-four hours preceding the operation. They received a preanesthetic dose of morphine sulphate, $\frac{1}{4}$ gr., and atropine sulphate, $\frac{1}{150}$ gr. The operation was done under light ether anesthesia. The animals were then returned to individual cages and offered water. If they survived the operation twenty-four hours, they were offered food.

Experiment 1.—In this experiment an effort was made to ascertain whether the amount of fresh, ground liver placed intraperitoneally in-

fluenced the interval of time the animals survived. Varying amounts of liver were introduced into four dogs through small laparotomy incisions. Table I shows the results of the experiment.

In Table I, we give the data on four dogs only. The findings, however, are in agreement with general observations which we have made numerous times; namely, that fresh liver, even in small intraperitoneal doses, makes the animals acutely ill, but survival does occur. Dog 304, which received $\frac{1}{2}$ gm. per kilo, a total dose of 5 grams of fresh liver, was prostrated for a number of hours, refused food, and for several days vomited blood. Smears and cultures made from peritoneal exudate removed eighteen hours postoperatively, were positive for the dog liver anaerobe. This dog, however, made a complete recovery in three weeks. We conclude, therefore, that the amount of liver introduced does have

TABLE I

THE EFFECT OF PLACING VARYING AMOUNTS OF FRESH, GROUND, ADULT DOG LIVER INTRAPERITONEALLY

	AMOUNT OF LIVER INTRODUCED THROUGH LAPAROTOMY INCISION		RESULT	SMEAR PERITONEAL EXUDATE 18 HR. POSTOPERATIVE	CULTURE PERITONEAL EXUDATE 18 HR. POSTOPERATIVE
	TOTAL GRAMS	GM. PER KILO			
Dog 304	5.0	$\frac{1}{2}$	Survived	Positive for dog liver anaerobe	Positive for dog liver anaerobe
Dog 301	17.5	1	Died 48-55 hours	Positive for dog liver anaerobe	Positive for dog liver anaerobe
Dog 302	37.5	3	Died 25-32 hours	Positive for dog liver anaerobe	Positive for dog liver anaerobe
Dog 303	67.5	5	Died 21-25 hours	Positive for dog liver anaerobe	Positive for dog liver anaerobe

a bearing upon the interval of time the animal survives. When, however, fresh, ground, adult dog liver is used in amounts of 30 grams or more, the animals all die rapidly, having the clinical appearance of shock associated with bacterial growth in the peritoneal cavity. When these larger amounts of liver are used, the calculated dose per kilo has little relationship to the time the animal survives.

Experiment 2.—This experiment was undertaken to determine the changes in blood chemistry which occurred following the intraperitoneal introduction of 100 grams of fresh, ground, adult dog liver. Six dogs were used. The following blood studies were done on the animals before placing the liver material intraperitoneally and later when the animals were moribund: red and white cell counts with the hemocytometer; hemoglobin estimation in the Haden-Hausser hemoglobinometer;⁹ coagulation time by the venous puncture and test tube methods;¹⁰ carbon dioxide capacity of the plasma by the Van Slyke volumetric method;¹¹ blood volume, plasma volume, and hematocrit number by the injection of vital red dye after the method of Hoople, Smith, Belt and Whipple;¹² blood sugar determinations, using the Folin and Wu macromethod

nonprotein nitrogen by nesslerization;¹⁴ total nitrogen by the macro-Kjeldahl method;¹⁵ blood chlorides as NaCl following the Volhard principle, using the Whitehorn procedure,¹⁶ and the blood urea nitrogen by use of the Leiboff pressure tube.¹⁷

The liver material was obtained from sacrificed dogs, ground and placed intraperitoneally in the same manner as described in Experiment 1. All of the animals died from eleven to seventeen hours following the introduction of liver. Bacteriologic smears and cultures from peritoneal exudate, removed as the dogs were dying, showed the dog liver anaerobe to be present in each case. Since the findings in all 6 animals were similar, the results can best be shown by including a typical protocol and table. Table II shows physical and chemical changes in the blood observed when 100 grams of fresh, ground, adult dog liver are placed intraperitoneally.

PROTOCOL

2/3/36

DOG 294

TABLE II

A short-haired, male cur, well nourished and healthy. The animal had been starved for twenty-four hours and weighed 16.8 kilos.

4:15 P.M.—Samples of blood were taken for blood cell counts, coagulation time, and blood chemistry analysis.

9:00 P.M.—Given a preanesthetic of $\frac{1}{4}$ gr. morphine sulphate and 1/150 gr. atropine sulphate.

10:20 P.M.—Given a general ether anesthetic and prepared for aseptic surgery.

10:40 P.M.—Three-inch laparotomy incision made through the right rectus muscle.

10:45 P.M.—One hundred grams (6 grams per kilo) fresh, ground liver introduced intraperitoneally.

10:55 P.M.—Laparotomy incision closed and animal returned to kennels.

2/4/36

9:40 A.M.—Animal lying on side in coma. Breathing was slow and labored, and the pulse weak and thready. The dog was passing bloody mucus from the bowel.

9:45 A.M.—Samples of blood were removed for cell counts, coagulation time, and chemical analysis.

10:15 A.M.—Animal was dying. Ten c.c. of peritoneal exudate were removed by pushing a hot, 15-gauge, perforated needle through a cautery burn in the abdominal wall. Bacterial smears and cultures were made of the peritoneal exudate. Both smear and culture were positive for the dog liver anaerobe.

The animal lived eleven and a half hours after the liver material was introduced intraperitoneally.

In general, the blood changes observed in these animals were definite and consistent. Following the introduction of ground liver intraperitoneally, there was a concentration of red blood cells and hemoglobin. The total nonprotein nitrogen, total nitrogen as protein, and urea nitrogen were increased. The carbon dioxide capacity of the plasma, plasma volume, blood volume, blood sugar, blood chlorides, and coagulation time were decreased. The white cell count varied with different

animals; some showed an increase, others a decrease. In most instances the results obtained confirm the findings of Mason, et al.,¹ when chunks of fresh dog liver were allowed to autolyze in the peritoneal cavity of the dog. The one notable exception is that we find a marked decrease in the coagulation time. Our studies further show that there is a marked concentration of blood, as indicated by increased red cell count, increased percentage of hemoglobin, and decrease in plasma volume. The hematocrit determinations, however, would seem to show very little change in the animal reported in Table II. Our experience has taught us that hematocrit determinations are subject to considerable error.

The necropsy findings in these animals were characteristic and agree with the findings of others who have investigated the problem. The

TABLE II

PHYSICAL AND CHEMICAL CHANGES IN THE BLOOD BROUGHT ABOUT BY THE INTRA-PERITONEAL INTRODUCTION OF 100 GRAMS OF FRESH, GROUND, ADULT DOG LIVER

DOG 294	NORMAL	AT DEATH 11½ HOURS
R.B.C.	7,370,000	10,230,000
W.B.C.	9,700	3,200
Coagulation time	2 min.	40 sec.
Hemoglobin—gm. per 100 c.c.	14	18
CO ₂ Vol. %	60	56
Hematocrit—% cells	50	53
Per cent Plasma	50	47
Plasma Volume in c.c.	1,258	740
Blood Volume in c.c.	2,500	1,570
Blood Sugar—mg. per 100 c.c.	103	71
Total N.P.N.—mg. per 100 c.c.	18	57
Total N. (as protein)—gm. per 100 c.c.	26	30.1
Blood Chlorides as NaCl—mg. per 100 c.c.	502	465
Urea Nitrogen—mg. per 100 c.c.	9.7	22.8

peritoneal cavity contained from 200 to 300 c.c. of turbid brown fluid; masses of liver fragments were caught in the omentum; all the peritoneal surfaces were fiery red and congested. There was a serofibrinous exudate on all peritoneal surfaces. There was marked hemorrhagic enteritis, particularly in the mucosae of the gastric fundus, the duodenum, and ileum. The temperature of the peritoneal fluid was 105° to 107° F. No free gas was noticed when the animals were examined at the time of death. The lungs were pink with congestion, and bled freely from the cut surface. The results obtained indicated that the animals die with all the cardinal signs of shock, as proved by both clinical and laboratory findings. The various factors which may be responsible for the shock condition will be taken up later in the general discussion.

Mason and Nau² report that marginal portions of the liver lobes are less lethal than the same amount of liver material taken from the center of the lobes. They further state that marginal portions of the lobes are sterile while the central parts harbor bacteria. The authors used

from 30 to 35 grams of liver substance in their experiments. They concluded that the presence of bacteria in autolyzing liver probably contributes to the rapid death of the animal, but believe their action is largely that of bringing about a more rapid liberation of toxins from autolyzing liver fragments. Since our early investigations of the problem had shown the margins of adult dog liver consistently to contain bacteria, we decided to check Mason's observations.

Experiment 3.—The liver was removed from a sacrificed dog in the usual manner. A small piece of liver was removed from the margin of the lobe and a similar piece was removed from the central part. Both pieces of liver were shown by culture to harbor the dog liver anaerobe. The marginal portions of the liver lobes were trimmed away from the central portions and 100 grams of each fraction were placed intraperitoneally in two operated dogs through a laparotomy incision, in a manner described previously. Both animals died some fifteen hours later, at approximately the same time. It is probable that this lack of agreement with the findings of Mason and Nau is to be explained on the basis that we introduced larger amounts of liver. Our subsequent experiment bears out this concept.

Experiment 4.—It occurred to us that the rapid death of dogs subjected to intraperitoneal introduction of fresh, ground, dog liver might be due in part to factors related to the laparotomy wound. We, therefore, minced the liver material finely enough to be injected through a 15-gauge needle. This was accomplished by placing 120 grams of fresh, ground liver plus an equal volume of sterile normal saline in a 500 c.c. Erlenmeyer flask, together with a small handful of broken glass. The flask with its contents was placed in a mechanical shaker and violently shaken for fifty minutes. The preparation was then filtered through six thicknesses of gauze. This procedure results in the almost complete separation of cells and parenchymal tissues of the liver from blood vessels, bile ducts, and connective tissue. After straining the preparation, it was found that 70 grams of parenchymal liver tissue plus 120 c.c. of normal saline had passed through the gauze, while 50 grams of the original amount of liver remained behind as blood vessels, bile ducts, and connective tissue. The fragments of broken glass were removed from this fraction. Cultures taken of both fractions were positive for the dog liver anaerobe. The 50 grams of blood vessels, bile ducts, and connective tissue plus 120 c.c. of normal saline were placed intraperitoneally in a dog through a laparotomy incision. The fraction of liver containing the 70 grams of parenchymal tissue was injected intraperitoneally in a similar dog through a 15-gauge needle. In this experiment the animal which received the 50 grams of liver blood vessels, bile ducts, and connective tissue presented the usual clinical picture of shock and died twenty-five to thirty hours following the operation. Post-mortem examination revealed intense peritoneal congestion and peri-

tonitis. On the other hand, the animal which received 70 grams of parenchymal elements of liver survived. At no time did the dog appear to be acutely ill. A sample of peritoneal exudate was removed twenty hours after the introduction of liver material. Stained smears made of this exudate were negative for vegetative forms of bacteria. A culture made of the exudate, however, was found positive for the dog liver anaerobe after three days' incubation. This was due probably to the presence of spores. The experiment was repeated with identical results. In this repeat experiment the animal which received the parenchymal elements was explored thirty-six hours following the implantation of liver material. There was some free fluid in the peritoneal cavity, and large masses of liver material were caught in the omentum. There was no violent congestion of peritoneal surfaces, such as is commonly seen when fresh whole liver is placed intraperitoneally. The incision was closed, and the animal made an uneventful recovery. Cultures and smears made of the peritoneal exudate at the time of this second operation were negative for any bacteria.

The results obtained in these preliminary experiments indicated that the parenchymal element of liver is much less toxic in its effects than the blood vessel, bile duct, and connective tissue elements. Furthermore, they indicated the surprising ability of the dog to sterilize large amounts of this contaminated material.

To check further the above observations and at the same time to ascertain whether the method of introducing the parenchymal elements of liver intraperitoneally influenced the results, the following additional experiment was carried out: The parenchymal element obtained from fresh livers removed from sacrificed animals in the usual manner was introduced intraperitoneally in 4 dogs. The dose of liver material equaled 6 grams per kg. In each of 2 dogs of this series, the parenchymal liver suspension was injected intraperitoneally through a needle. Each of the remaining 2 received the parenchymal liver suspension through a small laparotomy incision. All of these animals survived, and none appeared to be acutely ill. The dogs were given general ether anesthesia thirty hours after the introduction of the liver, and samples of peritoneal exudate were removed, using the cautery and needle technique. Smears made of these exudates showed large numbers of pus cells but no bacterial forms. Two of the cultures remained negative, while 2 were found positive after three days' incubation. The results obtained in this experiment confirmed those obtained in the preliminary experiments in every detail. They indicate that the manner of introducing the liver material intraperitoneally has no apparent effect upon the results. They further substantiate the previous observation that the cellular element of liver is decidedly less lethal in its effect than are the blood vessel, bile duct, and connective tissue elements. We believe that these results offer a satisfactory explanation of the observations re-

ported by Mason and Nau⁸ that marginal parts of liver lobes are less lethal than central parts, since the periphery of the liver lobes contains a relatively larger proportion of parenchymal elements. We find that the dog liver anaerobe is present throughout all the liver substance. Since 70 grams of the parenchymal elements of liver were shown not to be lethal when introduced intraperitoneally in the experimental animal, it followed that a determination of physical and chemical changes in the blood brought about by the injection of such material would be of interest. Experiment 5 was therefore carried out.

Experiment 5.—Two 70-gram lots of the parenchymal elements of liver were prepared and injected into 2 dogs in the same manner as described in Experiment 4. Physical and chemical determinations were made upon samples of blood removed from these dogs before the liver material was placed intraperitoneally, and repeated twenty hours later. The results of the experiment are shown in Table III. Both of these animals survived the operation.

TABLE III

THE PHYSICAL AND CHEMICAL CHANGES IN THE BLOOD BROUGHT ABOUT BY THE INTRA-PERITONEAL INTRODUCTION OF 70 GRAMS OF THE PARENCHYMAL ELEMENTS OF FRESH, GROUND, ADULT DOG LIVER

BLOOD STUDIES	DOG 273		DOG 274	
	NORMAL	AFTER 20 HR.	NORMAL	AFTER 20 HR.
R.B.C.	7,000,000	7,400,000	6,880,000	7,320,000
W.B.C.	12,950	15,200	17,700	14,200
Coagulation Time	3' 30"	30"	2' 40"	40"
Hemoglobin—gm. per 100 c.c.	13	13	13	13.5
CO ₂ Vol. %	72	50	63	56
Hematocrit—% cells	49	46	49	48
Per cent Plasma	51	54	51	52
Plasma Volume in c.c.	1,330	1,294	1,010	1,050
Blood Volume in c.c.	2,600	2,390	1,980	2,020
Blood Sugar—mg. per 100 c.c.	87	98	100	93
Total N.P.N.—mg. per 100 c.c.	40	46	30	36
Total N. (as protein) gm.	14.2	21.3	13.8	21.4
Blood Chlorides—mg. per 100 c.c.	465	485	500	495

A comparison of Tables II and III shows that, in general, both physical and chemical changes in the blood are much less marked in animals subjected to the intraperitoneal introduction of 70 grams of parenchymal elements of the liver. For the most part any changes observed in Table III are almost within the limit of technical error. The increase in total nitrogen of the blood and the decrease in coagulation time and carbon dioxide capacity of the plasma were the same in each instance. These animals never showed any marked evidence of shock.

DISCUSSION

Our experiments show that when dogs are subjected to the intraperitoneal introduction of 30 or more grams of fresh, ground, adult dog liver, the animals die usually within twenty-four hours, with all the

cardinal signs of shock. Furthermore, physical and chemical changes in the blood closely correlate those reported by numerous investigators on the subject of experimental shock. We believe, therefore, that shock is the major factor contributing to the rapid death of the animals. The factors which initiate the shock condition are not determined. It is not the purpose of this report to discuss the different theories which have been advanced to explain the mechanism of traumatic or secondary shock. At the present time there is considerable confusion in the literature as to whether secondary shock is caused by the absorption of toxic substances which cause a relaxation and increased permeability of the venules and capillaries, or whether the entire shock syndrome is due to hemorrhage and loss of body fluids.

It has long been known that trauma to abdominal viscera is one of the most effective measures in establishing a condition of secondary shock in the experimental animal. It follows that the intraperitoneal injection of any chemical substance with irritating qualities might be expected to accomplish the same result. Andrews, Rewbridge and Hrdina³ reported that 10 per cent solutions of bile salts placed intraperitoneally caused rapid death of the animal. Since they found large anaerobic bacilli in the peritoneal exudate, they attributed the rapid death of the animals to the pathogenic nature of these bacteria. We repeated their experiment, using more precaution against contamination of the peritoneal cavity, and observed that although the animals died the typical rapid death, the peritoneal cavity remained sterile. Postmortem examination revealed 300 to 400 c.c. of bright red fluid in the peritoneal cavity, with intense congestion of the viscera. Obviously, it is not necessary that bacteria play any rôle in the death of animals subjected to this type of chemical peritonitis. It is open to question whether the fatal shock condition of the animal was due to irritation of peritoneal surfaces, with loss of fluids intraperitoneally, or whether there was likewise the absorption of toxic substances which caused damage to parenchymatous organs and capillary dilatation and congestion elsewhere in the body. The intense enteritis, particularly in the ileum and duodenum, and the petechial hemorrhages on all visceral surfaces would indicate that there is actually an absorption of toxins. Mason and Nau⁶ have reported that following the intraperitoneal implantation of sublethal amounts of fresh liver, there is marked toxic degeneration of the liver and kidney. We have made similar observations upon animals subjected to intraperitoneal implantations of various preparations of liver. We have noted furthermore that the adrenal glands show definite pathologic changes, amounting in some instances to actual necrosis of the gland. It is possible that part of the disturbance in water balance and the shock condition of the animal can be attributed to absorption of toxins, which cause acute degeneration and exhaustion of these parenchymatous organs. It is logical that the increase in total nonprotein

nitrogen and urea nitrogen, and the marked alteration of blood sugar occur as a result of acute damage to the liver, kidneys, and adrenal glands. Moon and Kennedy¹⁸ published an excellent paper on the pathology of shock, in which they contrast the shock picture produced from gross hemorrhage with that produced by trauma to an extremity, or the intraperitoneal introduction of ground sterile muscle. In both latter instances there was marked capillary damage and dilatation, particularly in the lungs and gastrointestinal tract. These changes in the capillaries were not seen in the dog subjected to gross hemorrhage. The mere fact that shock can be caused by hemorrhage and loss of fluids alone, does not preclude the possibility that the absorption of toxic substances can likewise be the cause of secondary shock. Krogh¹⁹ has demonstrated that capillary change and relaxation can be produced by a wide variety of chemical substances.

We found, however, that the intraperitoneal introduction of 70 grams of the parenchymal elements of fresh liver was essentially harmless to the animal. The dogs failed to present the marked picture of shock seen in animals subjected to an equivalent amount of fresh, ground, whole liver. On the other hand, 50 grams of the blood vessel, bile duct, and connective tissue fraction of liver caused the typical shock picture and death of the animal. We further observed that animals injected with the cellular elements of liver were able rapidly to sterilize the material, while animals receiving the other fraction died with bacterial growth in the peritoneal cavity. We do not know whether the presence of the dog liver anaerobe in the peritoneal cavity of these latter animals contributed to, or caused, the condition of shock. It is possible that their presence was coincidental and could be explained on the assumption that toxic substances from this particular fraction of liver blocked out the phagocytic defense powers of the peritoneum. It is also possible that the fresh, parenchymal elements of the liver were able to combine with any toxins present, and in this manner protect the animal against shock. Whatever the explanation, we have demonstrated that the toxicity of implanted liver material is associated with the blood vessel, bile duct, and connective tissue elements. We believe that this observation may have fundamental significance in determining the complexity of factors which operate in producing this particular type of experimental shock.

SUMMARY

1. Dogs, receiving intraperitoneal doses of 30 to 100 grams of fresh, ground, adult dog liver, die usually within twenty-four hours, showing all the signs and blood chemical changes of shock.

2. When the dose is less than 30 grams for an average dog, there is a definite relationship between the interval of survival and the amount of liver introduced. One dog receiving $\frac{1}{2}$ gram per kg. (5 grams total dose) survived indefinitely.

3. In the dogs which died, peritoneal smears and cultures taken shortly before death consistently revealed growth of the dog liver anaerobe.

4. We have found the parenchymal elements of the liver to be relatively nontoxic. When these elements were separated from the blood vessel, bile duct, and connective tissue portions of fresh dog liver, 70 grams of the parenchymal tissue suspension caused neither death nor shock. However, 50 grams of the connective tissue suspension caused both shock and death.

5. Cultures taken of the parenchymal suspensions have consistently showed that this fraction of liver harbors the dog liver anaerobe. Nevertheless, smears and cultures of peritoneal exudate removed from dogs subjected to the intraperitoneal introduction of parenchymal suspensions of liver have shown that these animals rapidly sterilize the peritoneal cavity, even in the presence of large amounts of contaminated liver substance.

6. The dogs receiving the liver connective tissue suspensions rapidly died of shock and bacterial peritonitis, while the dogs receiving the parenchymal liver suspensions survived and remained well. This interesting observation merits further investigation.

We wish to express our appreciation to Dr. W. D. Gateh under whose supervision our investigations originated. Dr. Lynn Arbogast and Dr. Ralph Gettlefinger rendered valuable technical assistance.

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ACUTE APPENDICITIS

A REVIEW OF 518 CASES IN THE UNIVERSITY OF MINNESOTA HOSPITALS FROM 1932 TO 1935

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APPENDICITIS causes the loss of 20,000 lives each year in the United States; the highest mortality rate of any of the civilized nations. The mortality of appendicitis in this country was 11.4 per 100,000 population in 1910; 13.4 in 1920; 15.2 in 1929; and 18.1 in 1930. The average age at death in 1930 was 32.4 years. The victims of appendicitis die at a more productive age than the victims of tuberculosis (36.8 years), of cancer (60.7 years), of nephritis (62.2 years), or of heart disease (64.7 years). A survey of published statistics reveals a great variation in mortality, depending upon the method of classification of cases, and the type of treatment.

There has been no appreciable decline in the mortality of appendicitis in the past twenty years. In 16,424 cases of acute appendicitis, Stanton reports a mortality of 5.4 per cent. Twenty years ago, he found that it was 6.2 per cent in 4,343 cases. The degree of professional dissatisfaction with such results is indicated by the fact that over eight hundred articles on appendicitis have been written in the past four years.

The reasons for the high mortality in acute appendicitis may be summarized as follows: (1) delay by the patient in seeking medical advice, (2) inadequate medical treatment, (3) use of purgatives, and (4) mistakes in diagnosis. An important factor which has not been sufficiently stressed is the fact that the therapy employed in late cases with extra-appendiceal extension is often too radical and contributes to the high mortality.

The operative mortality bears a definite relationship to the duration of the acute inflammatory process. According to Stanton, about 30 per cent of the patients operated upon during the first day and 40 per cent of those operated upon during the second day of the disease present noteworthy peritoneal exudate. By the third day from 60 to 80 per cent of the cases present peritoneal involvement. At the same time, the operative mortality jumps suddenly to about 10 per cent. This increase involves chiefly those cases with periappendiceal complications, that is, abscess and peritonitis.

There would be no problem of appendicitis if all cases were operated upon early, that is, within twenty-four hours, as the mortality then would be less than 1 per cent (our mortality is 0.3 per cent for the un-

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In 95 cases operation was deferred, with one death. Operation in these 95 cases was deferred for the following reasons: (1) subsiding appendicitis, (2) duration of three days or more, and (3) acute upper respiratory infection, rheumatic fever, diabetes, and cardiac or renal disease.

Postoperative complications in these acute cases included 7 infected wounds, 5 instances of atelectasis, 3 of pelvic abscess, 2 of upper respiratory infection, and 1 each of bronchopneumonia, pleurisy, pyelitis, phlebitis, scarlet fever, pulmonary embolism, intestinal obstruction, and tapeworm. The single death in this group resulted from an infected hematoma and general peritonitis.

3. *Acute Appendicitis With Extraappendiceal Localization.*—In the third group, those with extraappendiceal extension (either local peritonitis or abscess) there were 107 cases (27 females and 80 males). The average age was thirty-one years.

Thirty-three were subjected to immediate operation, with two deaths.

Sixty-eight operations were deferred, with three deaths. Of these, 17 had abscesses drained and were advised to return for appendectomy, while 51 were discharged after conservative treatment and were advised to return six weeks later for appendectomy. Thirteen failed to return.

In the remaining 6 cases, no operation was advised because of advanced age, poor condition of the patient, etc.

The postoperative complications encountered in all cases with extra-appendiceal localization were 13 wound infections, 5 cases of bronchopneumonia, and 3 upper respiratory infections. There were 2 instances of intestinal obstruction, 2 of fecal fistula, 2 of postoperative hernia, 1 of paralytic ileus, and 1 of parotitis. Complications encountered before operation included 2 cases of infection of the urinary tract, 1 of osteomyelitis of the spine, and 1 of diabetes mellitus.

4. *Acute Appendicitis With General Peritonitis.*—There were 68 cases (13 per cent of the total number) in this group, of which 24 were females and 44 were males. Thirty-eight were under fifteen years of age. The average age was thirty years.

In 8 of these patients appendectomy was performed immediately.

In 45, operation was deferred. Of these, 32 were treated conservatively and advised to return for appendectomy in six to eight weeks. In 13, abscesses were drained and the patients were advised to return for appendectomy. (Five failed to return.)

In 15 cases no operative procedure was done. These patients were all desperately ill on admission. There were 23 deaths in 68 cases of general peritonitis.

Complications encountered in this group included 20 instances of localized abscess, 5 of pneumonia, 3 of atelectasis, 2 of wound infection, 2 of intestinal obstruction, and 1 each of pyelephlebitis with liver ab-

complicated cases). The real problem lies in the treatment employed when the disease has spread beyond the appendix. In many hospitals, it is routine practice to operate upon all cases of appendicitis when the diagnosis is made. The practice at the University Hospital has been more conservative, especially in dealing with late cases.

The treatment of appendicitis at the University Hospital, in brief, is as follows:

1. Every early case without clinical signs of periappendiceal extension is submitted to immediate operation.

2. Those which are apparently subsiding when first seen are allowed to subside completely before operation.

3. Conservative therapy, consisting of rest, hot packs to the abdomen, paraoral fluids, gastric siphonage, and sedatives, is carried out in most cases seen after the third day of the disease, and in all such cases with periappendiceal complications.

4. Transfusion and all other supportive measures are utilized in those patients with diffuse peritonitis.

5. Appendectomy, after conservative therapy, is deferred for from six to eight weeks to allow the inflammatory process to subside completely. Operation can be carried out more safely at the later date.

SURVEY

We present a series of 518 consecutive cases of appendicitis seen at the University of Minnesota Hospital from January 1, 1932, to January 1, 1935.

Of these 518 cases, 85 (16 per cent) were classified as "inactive." Two hundred fifty-eight (50 per cent) were acute but uncomplicated. One hundred seven (21 per cent) exhibited extraappendiceal localization (either abscess or local peritonitis). There were 68 with general peritonitis (13 per cent). There were thus 433 cases of acute appendicitis.

1. *Inactive Cases.*—This group consisted of 85 patients in whom the diagnosis was based upon the history alone. They were seen in a quiescent stage, the diagnosis having been made by the home physician who referred them to the hospital after the attack had subsided.*

Postoperative complications encountered in this group were 3 instances of wound infection, 2 of bronchopneumonia, 1 of upper respiratory infection, and 1 of atelectasis.

2. *Uncomplicated Acute Cases.*—There were 258 cases of uncomplicated acute suppurative appendicitis, of which 131 were females and 127 males. The average age of the group was twenty-one years.

One hundred sixty-three were operated upon immediately, without a death.

*Cases of acute appendicitis with complications, discharged from the hospital after conservative treatment and returning for operation, are listed under diagnosis made when they were first seen. For example, cases of generalized peritonitis treated conservatively, returning for operation, are listed as general peritonitis, etc.

of the cases with general peritonitis. Diarrhea was an infrequent symptom, being present in 7.7 per cent of the simple cases. Of the complicated cases, 20 to 25 per cent had diarrhea, of which one-fourth had taken cathartics.

Suppurative Complications.—Death in appendicitis is almost always due to intraperitoneal suppuration. Suppuration may localize in any quadrant of the abdomen, in the culdesac and in the subphrenic area. Suppurative pylephlebitis in this series was a rare complication.

Of 107 cases of localized suppuration 33 cases were submitted to immediate operation because of the failure to ascertain clinically that the process had spread beyond the appendix.

In 55 cases, because it was evident that an extraappendiceal complication was present, conservative therapy was instituted upon admission to the hospital. In only 17 of these did the inflammatory mass fail to resolve, necessitating surgical drainage of the abscess.

Forty-five cases of generalized peritonitis were treated conservatively. Twenty cases developed localized inflammatory masses; 13 of these necessitated incision and drainage in hospital. Seven subsided without surgical intervention.

Time of Operation.—Immediate operation was carried out in 47 per cent of all the acute cases. In 45 per cent, operation was deferred to a later date. Eight per cent of the cases were not operated upon.

Total Complications.—There were 22, or 3.8 per cent, wound infections; 25, or 4.8 per cent, respiratory complications. Five (1 per cent) of the cases developed intestinal obstruction.

ANALYSIS OF DEATHS FROM APPENDICITIS: JANUARY, 1932, TO JANUARY, 1935

There were 37 deaths in the whole group. Eight of these have been omitted from the study for the following reasons: one died from the anesthetic; 1 had severe Addison's disease and developed appendicitis while moribund from that condition; 1 was not seen by the surgical staff; 2 had appendectomy elsewhere and were admitted in extremis with diffuse peritonitis; the remaining 3 were moribund on admission, and died within 24 hours. This leaves 29 cases to be analyzed.

Sixteen of these were males and 13 were females. Nineteen were adults and 10 were children (15 years or under). The average age of the adults was 42 years. The average age of the children was 10 years, the youngest being 2 years. The average age of the entire series was 31 years. Thirty-five per cent of the patients gave a history of recurrent attacks. The duration of the symptoms prior to admission to the hospital averaged about 75 hours. Fifty-six per cent were seen 48 hours or more after the onset of the disease.

cesses, pyelitis, and postoperative hernia. Complicating factors encountered in this group were 4 cases of diabetes mellitus and 2 of hypertension.

Total Hospital Days.—The average hospital stay of those patients with uncomplicated acute appendicitis was 9.75 days; that of those with local complications (abscess, or localized peritonitis) 22 days; while those with general peritonitis averaged 23 days in the hospital. This includes the second stay of those readmitted for appendectomy.

Duration of Symptoms.—The duration of the symptoms prior to admission in the uncomplicated acute cases averaged 2.4 days. Sixty-six per cent of these patients were seen before 48 hours. The duration of symptoms in those with local complications was 6.1 days, 34 per cent being seen before 48 hours; while in those with generalized peritonitis, symptoms had been present for 3.5 days, 45 per cent being seen before 48 hours. Only 46 per cent of all cases were seen within 48 hours of the onset of symptoms.

Sixty per cent of the cases with simple acute appendicitis, 33 per cent of those with local peritonitis, and 70 per cent of those with general peritonitis gave a history of repeated attacks.

Cathartics.—Cathartics were taken by 6.5 per cent of the patients with simple acute appendicitis, by 29.0 per cent of those with localized findings, and by 28.0 per cent of those with general peritonitis. Forty-seven per cent of those who died had taken cathartics. Complete information was not available in all cases.

Bowers, analyzing the mortality record of twenty-eight Philadelphia hospitals, showed that of those taking no cathartic during the acute attack, 1 in 80 died; of those taking a cathartic once, 1 in 13 died; and of those who were purged more than once, 1 in 7 died. In a recent analysis Hobler found that repeated catharsis was associated with a mortality of 20 per cent. Since repeated catharsis usually means a late case, it is difficult to evaluate the exact influence of catharsis alone upon the mortality. There can be no doubt, however, that the increased peristalsis and resultant increased intraappendiceal pressure which obtains may cause perforation of a tense gangrenous appendix and lead to dissemination of the infection.

Physical Findings.—Pain and tenderness were the only constant findings, being present in all cases. The average temperatures were 99.2° F. for uncomplicated cases and 101.5° F. for those with extraappendiceal extension. The leucocyte count varied from 12,300 in the uncomplicated cases to 19,000 in the diffuse peritonitis group. The presence of a rapid pulse, a temperature over 101°, and an increased leucocyte count are the result of the systemic reaction following peritoneal contamination.

Chills were present in 3.8 per cent of cases of simple acute appendicitis, 11 per cent of the complicated cases with abscess, and 6 per cent

TABLE II

UNIVERSITY OF MINNESOTA HOSPITAL CASES FROM JANUARY 1, 1932, TO
JANUARY 1, 1935. (SPERLING AND MYRICK.)

	CASES	DEATHS	MORTALITY PER CENT
Inactive	85	0	0
Uncomplicated acute suppurative	258	1	0.30
Acute appendicitis with abscess formation	75	3	4.0
Acute appendicitis with local peritonitis	32	2	3.2
Acute appendicitis with general peritonitis	68	23	33.8
Total	518	29	5.6
All uncomplicated cases	343	1	0.29
All cases with complications	175	28	16.0
	518	29	5.6

COMMENT

Prior to 1929, every case of appendicitis admitted to the University Hospital was treated by immediate operation, regardless of the stage of the disease, unless the patient was moribund. Statistics from 1920 to 1929 have been summarized by Tasehe and Spano. It is apparent that there has been some improvement; that is, a decrease in mortality in that group of cases which presented some localization of the process at the time of admission (abscess or some local peritonitis). Our mortality in this group with abscess formation is 4 per cent. Reid, in a large series of cases treated by immediate operation, recently reported a mortality rate of 11.45 per cent. While it is obviously difficult to compare mortality rates in different series, such a difference would seem to be significant.

While there has been no great reduction in mortality rate in the group of cases with general peritonitis, it is noteworthy that the incidence of general peritonitis from 1932 to 1935 is four times that of 1920 to 1929; that is, 13 per cent as compared to 3 per cent. The mortality rate in this group of cases with general peritonitis, 33 per cent treated conservatively, compares favorably with that of other series in which all cases were submitted to immediate operation. (Reid.) Although from a comparison of mortality rates alone it would seem that some of these patients will die regardless of the type of treatment instituted, it is our clinical impression that these patients with general diffuse peritonitis, many of whom were desperately ill when first seen, having been transported one hundred to two hundred miles to the hospital, do better under the conservative treatment already described.

The question of when to operate is a difficult one, when patients are admitted late in the course of the disease. If it is plain that the process has already spread beyond the walls of the appendix, immediate operation is not recommended, although it is admittedly often difficult to determine whether perforation has occurred. A long history coupled with a moderately severe systemic reaction (fever of 101° F. or more,

Pain was present in all cases, nausea in 96 per cent, vomiting in 86 per cent, anorexia in 90 per cent, chills in 13 per cent, and diarrhea in 17 per cent (13 per cent with catharsis, 4 per cent without). A history of catharsis was obtained in 47 per cent (14 cases). The cathartic was prescribed by a physician in 3 of these instances.

Tenderness to abdominal and rectal palpation was present in all, rigidity in 97 per cent, rebound tenderness in 83 per cent, abdominal mass in 17 per cent, and a mass on rectal examination in 20 per cent.

The temperature on admission averaged 101.2° F. The average pulse was 112, and the average leucocyte count 19,100. Polymorphonuclears averaged 84 per cent. Total stay in the hospital averaged about 8 days. Eight patients lived less than three days after admission. Twenty of the entire group had diffuse peritonitis on admission. Eight had appendicitis with local complications (6 abscesses, 2 local peritonitis). One had simple acute appendicitis which was allowed to subside before operation, but died of complications incident to operation.

Seven of the cases were treated by immediate operation, and in an equal number operation was deferred. Fifteen were not operated upon. In the cases in which operation was deferred, incision and drainage of a pelvic abscess through the rectum was done in 3 cases, and colpotomy was performed in one. Two patients were operated upon because the question of strangulation obstruction arose. Both proved to have general peritonitis and died following operation.

Cause of Death.—Twenty-three of the 29 patients who died were subjected to necropsy. Four more had been operated upon, so that the diagnosis was definitely established in 93 per cent. General peritonitis was the cause of death in 24 cases. There were 6 cases of abscesses in the culdesac, 4 of pneumonia, 3 of atelectasis, 3 of diabetes mellitus, 3 of multiple abscess formation, and 3 of intestinal obstruction. There were 2 cases of pleural effusion, and 1 each of acute upper respiratory infection, of pylophlebitis with abscesses in the liver and gallbladder, of parotitis, of impetigo, of toxic nephritis, of local peritonitis, and of paralytic ileus. The cause of death was usually a combination of factors with the toxemia of general peritonitis a common denominator.

TABLE I

MORTALITY STATISTICS OF UNIVERSITY OF MINNESOTA HOSPITAL CASES FROM JANUARY 1, 1920, TO JANUARY 15, 1929. (TASCHE AND SPANO.) ALL TREATED BY IMMEDIATE OPERATION

	CASES	DEATHS	MORTALITY PER CENT
Inactive	339	1	0.3
Acute suppurative	72	1	1.4
Acute suppurative with local peritonitis	156	4	2.5
Acute suppurative with abscess	112	11	9.7
Acute suppurative with diffuse peritonitis	21	8	38.0
Total	700	25	3.4

This was done in order to search for gas under the diaphragm and thus rule out the presence of a perforating lesion of the gastrointestinal tract. These studies were all negative, including those in which perforation of the appendix had occurred; a walling-off process apparently effectually prevents any upward displacement of gas which may escape at the time of perforation. When the appendix ruptures, communication of the intestinal canal with the peritoneal cavity does not obtain in the same manner as when a break exists in the stomach or colon.

One should refrain from any attempt to remove the appendix when draining an abscess in the right lower quadrant, if the appendix is embedded in the adhesions forming the wall of the abscess. By too vigorous manipulation, this protective wall may be broken and the infection spread throughout the peritoneal cavity, with disastrous results.

Drainage.—Indiscriminate drainage of the peritoneal cavity is an error that contributes to postoperative complications, such as hernia, fecal fistula, adhesions, and intestinal obstruction. It results in a longer hospital stay and increases the mortality. It has been shown that draining the peritoneal cavity after an appendectomy, when only a cloudy protective fluid is found at operation, inhibits the defense reaction of the peritoneum. In such cases the patient makes a better recovery when the abdomen is closed tightly. Drainage without adequate indication is better omitted.

Incision.—The McBurney incision is employed at the University of Minnesota Hospital. When correctly made, it affords adequate exposure and may easily be lengthened in either direction. It approaches the peritoneal cavity from its lateral aspect, and should thus be unexpectedly encountered, it is drained through the lateral gutter instead of into the general peritoneal cavity. Shute recently reported the mortality for the right rectus incision as being 33.3 per cent in the diffuse peritonitis group, 30 per cent in the group with local peritonitis, and 33.3 per cent in those with early abscess formations; while for the McBurney incision he reported the mortality to be 16, 6, and 6.6 per cent respectively. Reid recently reported a decrease in mortality from 9.5 to 5.4 per cent since the routine use of the McBurney incision was adopted. It has been proved by experience that long incisions, allowing good exposure and free approach, are much safer than small incisions, which may necessitate too much traction during the most delicate part of the operation, that of freeing the diseased appendix. The edematous, gangrenous appendix may easily rupture during attempts to deliver it blindly through a "buttonhole" incision.

CONCLUSIONS

1. The mortality from acute appendicitis is still too high.
2. The probable reasons for this high mortality are (a) delay, (b) catharsis, (c) meddling surgery after the infection has spread beyond the appendix.

elevated pulse rate, and marked physical findings) usually point to peritoneal complications. In such cases conservative therapy is indicated.

Patients admitted with a mass in the right lower quadrant are likewise best treated conservatively when first seen. Many of these masses will disappear spontaneously without surgery, and the patient can return six to eight weeks later for operation when all the inflammatory reaction has resolved. If, however, fever persists, and a tender mass is encountered, it is apparent that an abscess is present, necessitating evacuation and surgical drainage. This is ordinarily best done through a lateral oblique incision which is an extraperitoneal approach. Collections of pus in the culdesae may be drained by colpotomy or incision through the rectum. Drainage per rectum carries with it a definite danger, as shown by the fact that two deaths followed this procedure. The introduction of bacteria from the rectum into the abscess cavity, establishing there a new bacterial flora, may have influenced the outcome. Incision and drainage of a pelvic abscess by rectum should be delayed until the mass is of good size and fluctuation can be demonstrated. Colpotomy in the female may be done without hazard. There were no deaths following this procedure.

It is very important to differentiate between an inflammatory mass about the ruptured appendix, which may gradually resolve, and a true appendiceal abscess with gross pus formation. The infiltration type of mass should be left alone; i.e., treated conservatively. The true abscess should be drained through some extraperitoneal approach.

Many of the localized masses, which were palpated on admission, disappeared under conservative treatment. Many of these when first seen no doubt represented loops of bowel matted together by omentum and fibrinous peritoneal exudate, and resolved without gross suppuration. In these cases, if fever persists and the mass does not recede in size, an accumulation of pus is usually present and should be evacuated. Further delay then is dangerous, as it invites rupture of the abscess into the general peritoneal cavity. Such a catastrophe is usually accompanied by a severe degree of shock, from which the patient fails to rally in spite of transfusions and other supportive means. Lethal exitus ensues very rapidly.

Suppurative pyelophlebitis may possibly have its origin in undrained collections of pus in the peritoneal cavity. This complication, however, was observed only twice in our entire series of cases.

Subphrenic infection follows perforated suppurative appendicitis not infrequently, but in our experience it usually subsides without the formation of an abscess requiring surgical drainage. In this series it was necessary to drain only one such subphrenic abscess.

In many of the cases of diffuse peritonitis which were treated conservatively, films were made with the patient in an upright position.

EVIPAL ANESTHESIA: A CLINICAL STUDY OF THREE HUNDRED CASES

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THE introduction of sodium evipal to clinical use has provided the surgeon with an anesthetic which is remarkable for its ease of administration, rapidity of induction, and freedom from unpleasant sequelae. Originally introduced as "the ideal anesthetic for short surgical procedures," this new drug is possessed, on the one hand, of certain properties which make its indiscriminate administration dangerous, and on the other hand, of unique qualities which render desirable a widening of its scope to include more than "short surgical procedures." In the following paper, certain characteristics of the drug with which we have been impressed during a two-year clinical study are reported.

Evipal, or evipan, was introduced as an intravenous anesthetic by Weese and Seharpff¹ in 1932. It is a white, water-soluble powder, now supplied in one gram sterile ampules to be dissolved in water at the time of use to make a 10 per cent solution. Chemically, it is related to barbital, as it is made by the methylation of the mild hypnotic phanodorn. The similarity of these compounds may be seen from the accompanying formulas (Fig. 1).

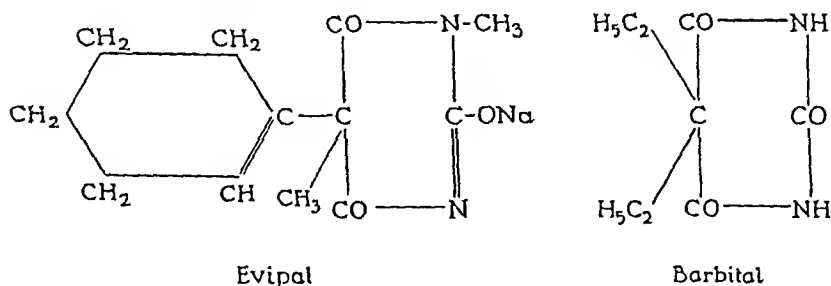


Fig. 1.

Most of the investigations upon which the clinical use of evipal has been based were conducted by Weese^{1, 2} in the laboratories of the I. G. Farbenindustrie, the German manufacturers of the drug. Weese reported that evipal had a wide margin of safety, as laboratory animals tolerated about three to four times the minimal active dose. When lethal doses were given, the respiratory center was affected before the heart, and if the anesthesia was not too deep, the animals could be

3. Every case of appendicitis in which the process is confined to the walls of the appendix should be operated upon immediately. Those with extraappendiceal complications, such as abscess or diffuse peritonitis, are best treated conservatively.

4. Operation after the first 48 hours of the disease should be done only in selected cases.

5. The operative mortality is highest from the third to the sixth day, as the operation is done while nature is still trying to localize the infection.

6. If an abscess is encountered at operation, too strenuous efforts to remove the appendix should be avoided, especially if it is buried in adhesions.

7. Buttonhole incisions are best avoided. That of McBurney is recommended.

8. Indiscriminate drainage of the peritoneal cavity predisposes to postoperative complications and should be avoided.

9. Drainage of culdesac abscesses per rectum carries a definite hazard and mortality. Colpotomy in the female is a relatively safe procedure.

10. Five hundred and eighteen consecutive cases of appendicitis are reviewed. An analysis of the 29 deaths in this group during the three-year period (1932-1935) is presented.

11. The mortality statistics of the group treated conservatively are sufficiently good to merit a continuation of this type of treatment in the hope that we will learn to use it more intelligently as time goes on.

12. The treatment of diffuse peritonitis is still unsatisfactory, and the mortality is still high (33 per cent).

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DUNPHY, ALT, AND REILING: EVIPAL ANESTHESIA

TABLE I

<i>General Surgery</i>		
Appendectomy		1*
Laparotomy		4
Colostomy		2
Herniorrhaphy		1*
Resutured abdominal wound		2
Débridement of burns		2
Minor amputation		2
Minor fracture		4
Excision of carbuncle		19
Biopsy		12
Incision and drainage		2
Miscellaneous		75
Hemorrhoidectomy		15
Fistula in ano		2
Proctoscopy		1
		2
		<hr/> 144
<i>Urology</i>		
Total cystectomy		1*
Cystectomy		2*
Suprapubic prostatectomy		3*
Transurethral prostatectomy		6
Ureteral transplantation		1*
Excision hydrocele		2
Circumcision		6
Dilatation of urethra		6
Cystoscopy		18
Incision and drainage of epididymis		1
Insertion of radium into prostate		1
		<hr/> 47
<i>Thoracic Surgery</i>		
Bronchoscopy		2
Esophagoscopy		3
Rib resection		6
		<hr/> 11
<i>Gynecology</i>		
Dilatation and curettage		6
Dilatation and curettage; biopsy of cervix		2
Pelvic laparotomy with drainage of pelvic abscess		2
Posterior colpotomy		
Cauterization of cervix		3
		<hr/> 1
<i>Ear, Nose, Throat</i>		
Drainage of antrum		14
Tonsillectomy		
Incision and drainage of peritonsillar abscess		10
Paracentesis of ear		2
Excision of nasal polyp		1
		<hr/> 1
<i>Dental</i>		
Extraction of teeth		15
Excision of root tip		
Incision and drainage of alveolar abscess		59
Reduction and wiring of fractured jaw		5
		6
		5
		<hr/> 75
Total		<hr/> 306

*Evipal used to supplement spinal or local.

revived by artificial respiration. In contrast to the previously known barbiturates, evipal was remarkably free from manifestations of increased excitability and was very quickly destroyed by the body. In the rabbit, one-half of the maximal narcotic dose was broken down in thirteen minutes. Weese considered the liver to be the principal detoxifying organ, because hepatectomized animals awoke more slowly from the effects of the drug than normal or nephrectomized animals. Maloney and Hertz³ have confirmed the observations of Weese in regard to the coefficient of effectiveness of evipal. They found the toxic-anesthetic-hypnotic ratio in rats to be 100:36:18. Observations on a small number of dogs have convinced us that freedom from excitability is not invariable; that morphine seems to deepen and prolong the anesthesia; and that there is a great individual variation in the effective dose, as Weiss⁴ has emphasized as a characteristic of the barbiturates.

CLINICAL OBSERVATION

During the last two years, over 300 operations have been performed under intravenous evipal at the Peter Bent Brigham and Beverly Hospitals. As can be seen from Table I, this included a wide variety of operative procedures. No attempt has been made to limit the use of evipal to the so-called "good-risk" patient, but in selected instances, we have used the drug whenever its singular qualities were particularly indicated. Comparatively few patients suffered, however, from conditions of serious magnitude other than the surgical condition requiring operation. A few were cardiac patients; one had intractable angina; six suffered from moderately severe diabetes; two had advanced tuberculosis; and three had chronic glomerular nephritis. In none of these cases were untoward reactions observed, but in all but one of these patients, the operative procedures were of a minor nature, and the amount of evipal used was less than 10 c.c.

In general, our observations are in accord with those of other investigators. The intravenous injection of sodium evipal usually induces the rapid onset of quiet anesthesia which is not unlike natural sleep. Respirations are slowed and slightly deepened. The pulse if previously rapid from excitement tends to slow, and frequently there is a fall in blood pressure. Tonic or clonic contractions of muscles, more or less generalized, may occur during the stage of induction. These seem to be particularly induced by painful stimuli, and many persist throughout the operation if full relaxation is not obtained. In favorable cases, with the use of preoperative medication, deep anesthesia sufficient to dilate the rectum or open the abdomen can be obtained. By the fractional administration of the drug, a method which we believe should invariably be employed, full anesthesia can be maintained for an hour or longer.

was given on five different occasions for the dilatation of an urethral stricture. Without preliminary medication 10 c.c. were required for the passage of only one or two sounds. After medication with 15 mg. of morphine and 100 mg. of luminal, satisfactory relaxation was obtained for several minutes with only 6 c.c. of evipal. The recovery period was not prolonged by the use of the preliminary medication. The third characteristic of evipal anesthesia with which we have been impressed is the tendency of the drug to cause a fall in blood pressure. According to Jarman and Abel,^{5, 6, 7} who have had a very extensive experience with evipal and whose excellent contributions should be read by all who use the drug, evipal uniformly causes a fall in blood pressure. This has not been our experience, possibly because we have taken pressure readings at five-minute intervals and may have overlooked a brief transitory fall in pressure occurring during the first few minutes of anesthesia. However, in 100 cases in which we have recorded the blood pressure at five-minute intervals, a significant variation, 20 mm. of mercury or over, has occurred in forty. In twenty-nine of these, there was a considerable fall; in three, a definite rise; in six, a fall followed by a rise; and in two, a rise followed by a fall. A fall in blood pressure when it occurs may be very marked, however, and as Jarman and Abel have emphasized, a patient whose blood pressure is already abnormally low should not be given evipal. The fall in blood pressure has been so striking in some of our cases that we feel that the prolonged use of evipal in major cases might predispose to shock. The exact mechanism of the fall in blood pressure has not been determined.

Fourth, the effect of evipal on the respirations is of considerable importance. The drug is a definite respiratory depressant. This has been emphasized by all observers and unquestionably constitutes a real danger. In 15 per cent of our cases, slight cyanosis has persisted throughout the operation although an adequate airway was maintained, and in two cases transitory cessation of respiration occurred. In both of these latter cases too rapid administration of the drug was made. Fortunately respirations were resumed almost immediately without the necessity of supportive measures. In addition to a depression of the respiratory center under evipal anesthesia, temporary obstruction to the air passage may occur from falling back of the tongue and relaxation of the jaw. This fact indicates the need of an anesthesiologist in addition to the one administering the drug. Finally, in certain cases evipal may induce severe asthma. We have had two such cases, and Feldweg⁸ strongly cautions against the use of evipal in asthmatics. In both of our cases, the attacks came on almost immediately after the injections were started. They were characterized by marked cyanosis, stridor, and irregular labored breathing. In both

Most observers consider rapidity of recovery to be one of the advantages of evipal anesthesia, but we have found that the recovery rate varies considerably with the duration of the anesthesia. In simple cases, where only 3 to 5 c.c. of the drug are used, recovery is usually immediate and is remarkably free from unpleasant after-effects. Occasionally, however, even with small doses, recovery may be prolonged. Thus, in one case for no apparent reason, the recovery rate was prolonged to ninety minutes following the administration of only 5 c.c. of evipal. When large doses are used, the recovery period is greatly prolonged. We have had patients remain unresponsive for several hours following the administration of intravenous evipal in amounts varying between 12 and 20 c.c. Although the recovery period even in these cases is usually free from unpleasant sequelae, from the point of view of the rapidity of the recovery alone, evipal has proved inferior to nitrous oxide for operations of long duration. In our experience, the use of carbon dioxide inhalations and coramine injections has not shortened the recovery period, but it is only fair to say that we have used coramine in small doses only.

Certain features of evipal anesthesia require particular emphasis. First, evipal possesses the disadvantage common to all intravenous drugs, that once administered, its action is irrevocable. This fact alone renders the fractional method of administration imperative. Moreover, this inherent danger of the intravenous route is increased by a great individual variation in the effective dose. Thus, in one instance a young boy weighing only 134 pounds required 20 c.c. of evipal before sufficient relaxation was obtained to incise and drain an abscess of the leg, a procedure lasting only six minutes, while in another case, 6 c.c. permitted the total excision with endothermy of a large carbuncle of the neck in a woman weighing 229 pounds. The latter procedure lasted ten minutes. *It is obvious, therefore, that no rule can be established in regard to dosage and, as described below, the fractional method of administration should invariably be used.*

It follows as a corollary of this variation in the effective dose that certain patients are highly resistant to evipal anesthesia. In 5 per cent of our cases, 10 c.c. or more of evipal have failed to produce sufficient relaxation, even with preoperative medication with morphine; and in another 10 per cent, the relaxation, although sufficient to permit operation, has not been satisfactory. This constitutes one of the chief disadvantages of the drug, because as yet there is no way of predicting which patient will prove resistant. Two of our patients who were particularly difficult to anesthetize with evipal were negroes.

It is our impression that the preoperative use of morphine is of definite value in obtaining more satisfactory relaxation. This was very strikingly exemplified in the case of a young negro to whom evipal

was given on five different occasions for the dilatation of an urethral stricture. Without preliminary medication 10 c.c. were required for the passage of only one or two sounds. After medication with 15 mg. of morphine and 100 mg. of luminal, satisfactory relaxation was obtained for several minutes with only 6 c.c. of evipal. The recovery period was not prolonged by the use of the preliminary medication.

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eases the attacks subsided as soon as full anesthesia was obtained, but recurred in an equally alarming manner during the recovery period. For the present, we consider a history of asthma to be a contraindication to evipal.

Rapidity of recovery and freedom from unpleasant sequelae are considered to be two of the great advantages of evipal anesthesia. Except as we have already emphasized, that recovery may be greatly prolonged if large doses are used, our experience confirms this impression. Nausea and vomiting are rare, occurring in 2 per cent of our series. Headache is not common; it occurred in 6 per cent of our patients. Postoperative excitement is occasionally encountered, particularly in alcoholics. Although usually transient, it rendered one of our patients quite unmanageable for several minutes after regaining consciousness. Pulmonary atelectasis occurred in 3 per cent. As most of our patients suffered from comparatively minor surgical conditions, it is fair to say that in major surgery the incidence of pulmonary atelectasis would not be lower after evipal than after another general anesthetic.

A postoperative complication of considerable importance is a state of amnesia. Five of our patients suffered from this condition for periods of thirty minutes to twelve hours after apparent complete recovery. We consider this a contraindication to the use of evipal on out-patients, unless they are to be hospitalized or special arrangements are made to care for them during their return home. Other examples of damage to the nervous system following evipal anesthesia are the case of complete paralysis of the trunk, lower limb, and distal portions of the upper limbs reported by Landor and Salleh;⁹ the case of markedly increased intracranial pressure reported by Landau and Wooley;¹⁰ and the case of polyneuritis reported by Palmer.¹¹ It is difficult to evaluate these complications. We have had no similar difficulties, and none have been observed in the very large series of Jarman and Abel.⁶

FATALITIES

Reported fatalities due to evipal anesthesia have been rare. Stimpfl¹² in an analysis of eleven deaths found in most cases a relative overdosage. It is worth noting, however, that all of his cases received less than 10 c.c. of evipal, and in one instance only $4\frac{1}{2}$ c.c. This again serves to emphasize the importance of individualization in the use of sodium evipal intravenously. Attention must be directed, not so much to the total amount, as to the time in which any given amount is administered. In Stimpfl's cases, the manner of death appeared to be equally divided between respiratory and cardiac failure.

In our own experience there have been no fatalities attributable to evipal anesthesia, although three patients who have had evipal have died; one, two days after operation, and the others, ten days after

operation. In all three cases, recovery from the anesthesia was complete, the patient dying of the condition for which the operation was undertaken. One of these cases, that of a man forty-five years of age who was suffering from extensive actinomycosis of the lungs, pleura, liver, and brain, is of particular interest. This patient received evipal on six different occasions, five of them within a period of five weeks before death. The total amount given was 30.5 c.c. Careful post-mortem studies of the brain, liver, and kidneys have shown no changes which could be attributed to evipal.

TECHNIC

After a study of our first one hundred evipal anesthetics, the following technic was adopted, and is being used at present with minor variations at the Peter Bent Brigham and Beverly Hospitals:

(a) *Preoperative Preparation*.—Breakfast is withheld from patients routinely. On several occasions we have given evipal to patients within an hour after a heavy meal without ill effects, but this should be avoided if possible, as untoward reactions have been reported.¹³ For procedures of short duration, such as the incision and drainage of a small abscess, no preliminary medication is given. For a longer operation such as cystoscopy, transurethral resection, rib resection, or abdominal section, preliminary medication with morphine in doses of 10 to 15 mm. is given one hour before operation. It has been argued¹⁴ that to add the depressant action of morphine to that of evipal increases the danger of respiratory paralysis. We are entirely in sympathy with this view, but feel that if the fractional method of administration is used, there is not sufficient danger of respiratory paralysis to contraindicate premedication with morphine. Without premedication the scope of evipal anesthesia is greatly limited, and increased dosage must be given.

(b) *Administration*.—The operative field is completely prepared before starting the injection. A suitable vein in the antecubital fossa is selected, and the arm extended in a comfortable position on an arm board. In our earlier experience, we insisted upon having an anesthetist present in addition to the one giving the anesthesia to keep an accurate record of pulse, respirations, and blood pressure, and to hold the jaw, insert an airway, or administer oxygen if necessary. At present, in minor cases, a record of pulse, respirations, and blood pressure is occasionally omitted. The drug is dissolved in sterile water several minutes before the final preparations of the patient are completed. Having the drug in solution for several minutes before the injection seems to help minimize tremors. Injection is made with a 10 c.c. Luer Lock Syringe, using a good sized needle (No. 19), because if the operation is prolonged, there is less danger of clotting.

(c) *Dosage*.—As has already been emphasized, no rules regarding dosage can be established. To individualize correctly is the art of evipal narcosis. Depending upon the weight, degree of excitement, amount of preoperative medication, and general condition of the patient, we inject from 2 to 4 c.c. very rapidly (that is, 1 c.c. every ten seconds), and then wait thirty seconds to observe the result. This short pause following the initial injection is very important because as Killian¹⁵ has emphasized, although the curve of effectiveness of evipal rises very quickly, the maximum effect is always reached after several minutes, so that it is possible to exceed the minimal fatal dose during the first few seconds of administration. This is particularly important if preoperative medication is used.

In the vast majority of cases, following the initial injection, the patient, who has been instructed to count, suddenly stops counting, takes a long sigh, and passes into a fairly deep anesthesia. Then one more cubic centimeter is injected, and the operation started. As needed, more evipal is injected in amounts of one-half to one and one-half cubic centimeters. If tremor is marked or there is extreme rigidity, more evipal is needed. Apart from obvious signs of awakening such as moving or moaning, the most helpful indications of the depth of anesthesia have been the rigidity of the jaw and the size of the pupils. If anesthesia is deep, the pupils are large and fixed, while with regaining consciousness the pupils become smaller and react to light.

The question naturally arises as to how much evipal can be given at one time. Provided the condition of the patient is satisfactory, we have continued with the fractional administration of the drug until the operation was completed. In ten instances we have used between 12 and 20 c.c. of the drug and have observed no untoward effects. It may be said, however, in regard to large doses, that there seems to be a progressively greater depressant effect of the drug when larger doses are used, with the result that recovery is frequently greatly prolonged. Although amounts of evipal as great as 30 to 40 c.c. have been administered¹⁶ without apparent unfavorable result, our experience would lead us to be very cautious in using over 15 c.c.

(d) *Postoperative Management*.—Following the operation, the pulse, respirations, and blood pressure were taken at ten-minute intervals until full consciousness was regained. In minor cases this is no longer deemed necessary. Once consciousness has been regained, patients may be permitted to eat if they so desire. We have insisted upon patients remaining in the hospital overnight following evipal anesthesia. This was originally done as a precaution in the use of a new drug and to provide an opportunity for a careful observation of the recovery period. Because of the occasional occurrence of amnesia, however, we still hospitalize out-patients following evipal narcosis, making exceptions to this rule only in particular instances.

CONTRAINDICATIONS

Jarman and Abel⁷ consider liver damage, low blood pressure, the sitting position, and previous medication with barbiturates as definite contraindications to evipal. As the available evidence points to the liver as the principal detoxifying organ for evipal, it seems reasonable to consider jaundice, cirrhosis, or other evidences of liver damage as a definite contraindication. In our opinion, low blood pressure, the presence or imminence of shock, and marked debilitation also constitute definite contraindications. Agreeing with Feldweg,⁸ we do not use evipal on asthmatics.

Provided the potential dangers are appreciated and proper caution observed, however, we do not consider the sitting position an absolute contraindication to evipal any more than to avertin, which also causes a fall in blood pressure and depresses the respiratory center. Also, although we do not use barbiturates as a routine preoperative medication, on a number of occasions we have supplemented spinal anesthesia by evipal, although large amounts of luminal had already been given. No alarming reactions or difficulties were encountered. If the fractional method of administration is used, we see no reason why premedication with barbiturates should constitute an absolute contraindication to evipal.

INDICATIONS

Evipal has been hailed as the ideal anesthetic for surgical procedures which can be completed within fifteen or twenty minutes. Although it has proved preeminently satisfactory from the patient's viewpoint, it is far from being an ideal anesthetic. The fact that it is an intravenous anesthetic, and that once administered its action is irrevocable; the recognized uncertainty of its action based, perhaps, on individual idiosyncrasies to the drug; the occasional difficulty of venipuncture in obese patients; the long recovery period, if the operation is prolonged; the depression of respiration; and the necessity of having an anesthetist in addition to the one administering the drug, frequently have induced us to prefer nitrous oxide.

On the other hand, we feel that the scope of evipal anesthesia may be extended to operations which may require thirty to forty minutes or even longer for their completion, and we feel that the singular qualities of evipal make it the anesthetic of choice for many operative procedures. Notably among these are the supplementing of spinal or local anesthesia, certain operations on the head or face, the closure of disrupted wounds, and operations under circumstances in which cumbersome apparatus or means of restraining the patient during induction are not easily obtained.

The smoothness and rapidity of evipal induction renders it the anesthetic of choice to supplement spinal or local anesthesia on patients in

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tained, evipal is of great advantage. The question naturally arises as to whether or not evipal should be used in the office or home. Provided the necessary personnel to care for the patient and a supply of oxygen and carbon dioxide is available, this is permissible, and as knowledge of the drug increases, it may be used as freely in office practice as gas oxygen. At present, however, we would deprecate its use under circumstances in which a supply of oxygen and carbon dioxide, and an anesthetist in addition to the one administering the anesthetic are not available. Indiscriminate employment of the drug in our present state of knowledge may readily lead to fatalities which will discredit what seems to be a valuable adjunct to our anesthetic armamentarium.

SUMMARY

1. A clinical study of three hundred evipal anesthetics is presented.
2. Certain dangers and contraindications are discussed. The importance of individualization in the use of this new anesthetic is emphasized.
3. A technic of administration is given and particular indications for this type of anesthesia are outlined.

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good general condition. The change from a failing or incomplete spinal to general anesthesia can now be accomplished without the distressing struggle and disruption of the operative field which so often accompanied the change to ether or gas oxygen. Moreover, it is often surprising how long a spinal anesthesia can be supplemented by the use of only a few cubic centimeters of evipal. Combined with local anesthesia, evipal has proved equally efficacious. Thus, for example, in patients in whom a prolonged general or spinal anesthesia is inadvisable, the abdomen may be opened under local anesthesia, a few cubic centimeters given to permit excision of a bladder tumor, or enucleation of an enlarged prostate, and then the closure completed under local anesthesia.

For operations about the head and face, evipal is indeed ideal. It has been used extensively at the Peter Bent Brigham Hospital for dental work, including the reduction and wiring of fractured jaws. At the Beverly Hospital it has been used frequently in operations on the antrum, where it possesses the advantage that, although relaxation of the jaw is satisfactory, the cough reflex is usually preserved, preventing aspiration of foreign material. This preservation of the cough reflex, however, renders evipal somewhat less satisfactory for bronchoscopy and esophagoscopy than other anesthetics. Evipal has become practically the standard anesthesia at the Peter Bent Brigham Hospital for the incision or excision of large carbuncles of the neck, formerly always an annoying procedure under gas oxygen. It has also proved a great boon in the treatment of severe burns or lacerations of the face, requiring a general anesthetic for débridement and cleansing. It should be noted, however, that the enthusiasm for evipal in operations about the head and neck must not be extended to the treatment of deep cervical phlegmons, where any general anesthesia which relaxes the muscles of respiration and deglutition is dangerous.

Rapidity and ease of induction also makes evipal very satisfactory in the treatment of a disrupted wound. We have had two occasions to use it for this purpose, and not only has the relaxation been satisfactory, but the remarkable absence of struggling or straining during the induction has made what ordinarily is a most trying situation a comparatively easy one. It may be argued that the action of evipal is not sufficiently reliable to permit its use in so critical an emergency as a disrupted wound, but provided preparations are made to supplement with an inhalation anesthetic if necessary, this objection is not a valid one. Moreover, patients with disrupted wounds are often in rather poor general condition, and should require comparatively little evipal to obtain and maintain satisfactory relaxation.

Finally, under circumstances in which cumbersome apparatus, or means of restraining the patient during induction, are not easily ob-

whole blood. The average sum of these figures was 4.05 per cent which was the average total loss of plasma and whole blood. The figure for the whole blood is necessarily included, because the animals died before the red blood cells from the last bleeding had been replaced. The average increase in hemoglobin was 34 per cent of the control figures. When the bleedings were performed at six-hour intervals, the average loss was 2.4 per cent plasma and 0.2 per cent whole blood. The sum of these figures is 2.6 per cent which was the average total loss of plasma and whole blood. The average increase in hemoglobin was 24.0 per cent of the control figures.

Roome, Keith, and Phemister¹¹ found that an average plasma loss of 3.0 per cent body weight in a series of five dogs would reduce the blood pressure to a shock level. These authors found the terminal blood loss in this series to be 1.4 per cent body weight. This makes the total plasma and blood loss 4.4 per cent. The blood was concentrated by this procedure, but no figures in this regard are given in the report. The authors state that removal of less plasma than whole blood would produce death.

The amount of plasmalike fluid lost in various shocklike conditions has been found by various observers to be of the same order of magnitude as the figures quoted in the previous paragraph. This makes them of especial significance, and one of the purposes of this paper is to check them under slightly different circumstances. The maximal blood concentration producible by plasmapheresis has also not been thoroughly studied heretofore.

EXPERIMENTAL

Dogs under barbital anesthesia were used throughout. Blood was withdrawn from one femoral artery into centrifuge tubes containing sodium citrate, and after centrifuging and removal of the plasma, the cells were reinjected into the opposite femoral vein. In certain experiments this was done using aseptic surgical technique, in others only chemical cleanliness was employed, and the results in the two groups showed no marked difference. The blood pressure was recorded by means of a cannula inserted into the right carotid artery connected to a recording drum. Hemoglobin (Sahli) and hematocrit (Van Allen) determinations were made as controls and during the course of the experiment. Bleeding was performed at usually half-hour intervals or longer, and as the blood pressure fell, smaller and smaller amounts of blood were removed, so that the last lethal sample would be as small as possible. After centrifuging, the cells were reintroduced without dilution. The results of eight experiments are given in Table 1. It is seen that the amount of plasma removed averaged 4.0 per cent

BLOOD CONCENTRATION PRODUCED BY PLASMAPHERESIS

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SEVERAL workers have reported that in certain experimental or clinical shocklike conditions, there is an extensive loss of plasma-like fluid into a locally traumatized area. These authors have concluded that in many instances the amount of this fluid loss is sufficient to account for some of the symptoms present, and in certain cases to explain the resultant death itself. Analyses of the exudates have shown them to be similar to blood plasma in chemical composition, especially as regards protein content. Loss of such plasmalike fluid has been reported in burns,¹⁻³ freezing,⁴ bile peritonitis,⁵ tissue autolysis in vivo,⁶ pneumonia and pulmonary edema,⁷ portal and mesenteric obstruction,⁸ and following release of an extremity constrictor.⁹

The question naturally arises as to whether the amount of such fluid lost from the circulating blood stream in these cases is sufficient to account for the morbidity and mortality involved. The amount of blood which will produce death when lost from normal animals has been differently reported by various observers. Boyce, Lampert, and McFetridge¹⁰ reported that dogs could be bled 4.6 per cent body weight without shock or death resulting. Roome, Keith, and Phemister¹¹ reported that 4.5 per cent blood loss would produce death in dogs, and Johnson and Blalock¹² found the same figure to be 5.1 per cent. Elman and Cole⁸ found that death followed a 2.7 per cent loss of blood from hemorrhage in normal cats. Evidence obtained from plasmapheresis experiments indicates that experimental animals cannot tolerate the loss of plasma as well as whole blood. These latter experiments are open to the objection that the reinjection of centrifuged cells after the removal of plasma may introduce factors that must be reckoned with besides the plasma loss. The centrifuged cells even if not hemolyzed may hasten the occurrence of death in an already weakened animal. Johnson and Blalock¹² found that dogs would die after loss of varying amounts of blood plasma by plasmapheresis dependent on the time interval. When the blood plasma was removed in amounts equaling 0.5 per cent body weight at hourly intervals, the total amount removed in percentages of body weight varied from 2.5 per cent plasma and 1.0 per cent whole blood to 3.5 per cent plasma and 0.85 per cent

body weight and that the amount of blood at the terminal bleeding averaged 0.4 per cent, the total being 4.4 per cent. The average time from the first to the last bleeding was ten and one-half hours.

In Experiment 6, with 7 bleedings totalling 2,500 c.c. and following centrifuging, 1,075 c.c. of plasma were removed. Eighty c.c. of the 1,425 c.c. of cells were lost and not replaced. The last bleeding was done ten hours after the first, and after reintroduction of the cells, 300 c.c. of plasma were slowly reinjected intravenously over a period of fifty minutes. The blood pressure was 86 mm., or lower, beginning three hours after the first bleeding, except for a four-minute period when it rose to 112 immediately after reinjection of cells before the plasma infusion was begun. The plasma infusion had practically no effect on the blood pressure which fell to 46 nine hours later. The dog died about 20 hours after the first bleeding.

The average hemoglobin percentage in all the experiments before the plasmapheresis was begun was 95, and the final reading was 147. The initial and final hematocrit readings were 49 and 69 respectively. This represents an increase of 55 per cent over the control reading for the hemoglobin and 41 per cent for the hematocrit.

COMMENT

The unsuccessful attempt to restore one of the animals by reinjection of the removed plasma is in accord with attempts to treat some other types of plasma loss.⁵ No further discussion of this point will be made in the present paper. The amount of blood concentration obtained by radical plasmapheresis was found to be 55 per cent by hemoglobin estimation and 41 per cent by the hematocrit reading. No especial significance is attributed to the difference in these averages. Possibly with plasma depletion, the cells lost water to the surrounding substrate and shrank. This would account for the greater increase in hemoglobin than hematocrit readings. The average increase in blood concentration of about 50 per cent of the control reading is greater than that found by Johnson and Blalock¹² (24 to 34 per cent).

Johnson and Blalock's experimental observation that a smaller amount of plasma would kill when removed slowly than when removed rapidly is of interest. In our experiments, the time between the first and last bleeding varied from four hours to twenty hours, and no especial difference was noted in the lethal amount of plasmapheresis. It is possible that once the blood pressure has been lowered, the longer it is allowed to remain at a low level, the more precarious the state of the animal becomes and the less plasma needs to be removed later to produce death. This affords a possible explanation for Johnson and Blalock's results. It is also possible that the prolonged anesthesia

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may have been a factor. Seeley, Essex, and Mann¹⁵ have studied the relation of various types of anesthetic agents to the development of traumatic shock.

The amount of plasma removed in the eight experiments averaged 4.0 per cent body weight. This is considerably more than removed by Johnson and Blalock¹² in the plasmapheresis experiments previously cited. It is of interest that it is also more than has been reported in various other shocklike conditions: burns, 3.2 per cent (Blalock²), 2.2 per cent (Harkins³); freezing 2.6 per cent (Harkins, et al.⁴); release of an extremity constrictor, 3.5 per cent (Wilson and Roome⁶); bile peritonitis, 2.5 per cent (Harkins, et al.⁵); and intestinal manipulation, 4.5 per cent (Blalock¹³). With the exception of the fluid recovered in experiments on manipulated intestines, these figures are less than the amount of plasma which when removed by plasmapheresis will be fatal. The blood concentrations reported in several of these conditions, however, are as great as the maximal concentration produced by plasmapheresis. Moon¹⁴ has reported extensive blood concentration in several shocklike conditions, and it is possible that in them there is a general leakage of fluid from the capillaries all over the body, as well as at the site of the local lesion. Hence in these instances, the local loss of fluid may not be the only lethal factor and may not be the cause of all the blood concentration. In plasmapheresis on the other hand, especially when done rapidly, it seems likely that the plasma directly removed is the cause of most, if not all, the blood concentration and accompanying blood pressure fall.

SUMMARY AND CONCLUSIONS

1. The amount of plasma which, when removed from experimental animals, will produce death was 4.0 per cent body weight. This is more than the local fluid loss reported by various observers in other shocklike conditions, as well as following plasmapheresis itself.

2. The amount of blood concentration producible by plasmapheresis was not found to be greater than that in certain other shocklike conditions. It is possible, therefore, that in the latter there may be a generalized as well as a local fluid loss.

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lowing various stimuli. Further clinical pathologic studies and necropsy reports of animals with experimental hypothalamic hypertension will be submitted.

TABLE I

BLOOD PRESSURE RESPONSES IN HYPERTENSIVE AND NORMAL DOGS TO VARIOUS STIMULI

TEST	NORMAL DOGS		GOLDBLATT DOG		DOG WITH HYPOTHALAMIC INJURY	
	B. P.	PULSE	B. P.	PULSE	B. P.	PULSE
Test	136/ 83	110	200/120	118	242/130	80
Exercise	182/115	132	210/128	120	290/148	91
Nembutal anesthesia	90/ 70	84	190/110	90	120/ 60	110
Water at 5° C.	204/122	130	202/124	128	300/140	100
Insulin hypoglycemia	178/110	Variable	230/130	Variable	290/175	Variable

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PERSISTENT HYPERTENSION DUE TO HYPOTHALAMIC INJURY

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PERSISTENT elevation of the systolic blood pressure in experimental animals as the result of renal ischemia has recently been demonstrated by Goldblatt, et al.¹ This communication presents some observations on a canine with a resultant hypertension due to direct injury to the hypothalamus. The marked rise in systolic and diastolic blood pressure was discovered during routine postoperative studies on animals which had been subjected to procedures intended to produce diabetes insipidus. The hypothalamic area in a normal, mature, male beagle hound was exposed by the technique described by Crowe, Cushing, and Homans.² A three-millimeter transverse incision was made immediately posterior to the infundibulum, sufficiently deep to puncture the third ventricle in the midline. Five weeks following injury to the hypothalamus, the blood pressure had risen from a normal level to 242/130. Bradycardia was associated with the hypertension. As this phenomenon was striking, the animal was studied for a period of five months. During this time, the blood pressure remained persistently elevated. There were obvious pulsations of both axillary and femoral vessels. The femoral artery, on palpation, had a resounding snap, although no actual change in the vessel wall could be ascertained. There were no pulsations of the vessels in the eyegrounds, but increasing tortuosity and A-V nicking developed. No hemorrhages appeared in the fundi. Exercise augmented the pulse rate but slightly from a level of 88 to 100. There was a faint systolic whiff heard best over the base of the heart. Roentgen examination of the heart revealed evidence of cardiac enlargement of 23 per cent over a period of four months. No disturbance of carbohydrate or water metabolism developed. For purposes of comparison, blood pressure responses to various stimuli were carried out on canines with hypertension due to renal ischemia and on normal controls.

From Table I it can be seen that the animal with hypothalamic injury showed a more labile response to various stimuli. The increase in pulse rate under nembutal anesthesia has not been explained. The dog with hypertension due to renal ischemia showed a more fixed type of hypertension, with but slight change under nembutal anesthesia or fol-

In Memoriam

HOWARD L. BEYE
1886-1936

THE surgical profession has lost one of its brilliant younger members by the untimely death of Howard L. Beye, professor of surgery at the University of Iowa, who was killed in an automobile accident near Marshalltown on September 29, 1936.

Dr. Beye was born at Oak Park, Ill., on September 24, 1886. He graduated from the University of Wisconsin in 1909, and received his degree in medicine at Rush College in 1911. During the following year and a half, he served as interne at Cook County Hospital, and at once began teaching as an assistant in medicine at Rush. In 1914, he came to Iowa City as an instructor in surgery at the Medical School of Iowa State University under his friend and teacher, Dr. Charles Rowan. He was appointed professor of surgery in 1924, and three years later succeeded Dr. Rowan as active head of the surgical department. He served overseas during the World War and was wounded in action at Chateau Thierry. Shortly after returning to Iowa City, he was married to Ruth Ketchum of Oak Park, and to them have been born six children, four girls and two boys.

Dr. Beye's work in the field of surgery has won for him wide recognition and fellowship in outstanding societies. He was a member in good standing in the Johnson County Medical Society, the Iowa State Medical Society, the American Medical Association, the American College of Surgeons, the Western Surgical Association, the American Association of Thoracic Surgery, and the American Surgical Association. Some weeks before his death, Dr. Beye had consented to accept a place on the Committee on Publications of SURGERY.

Dr. Beye had a wide interest in the field of general surgery, as can be seen from the diversity of his contributions to surgical literature during the past twenty years, but unquestionably his chief interest of late has been in the diseases of the thorax. I know of no better way of paying adequate tribute to his work and character than by quoting from a personal letter which I received a few days ago from his associate of many years, Dr. Frank Peterson, now head of the department of surgery at Iowa City: "His particular interest, as far as surgery was concerned, had been in diseases of the thorax. He had been spending innumerable hours in study and in the laboratory improving his knowledge of the anatomy, particularly as related to the lung and mediastinum. Just a few weeks prior to his death he had done a masterly pneumonectomy for carcinoma of the bronchus, with remarkably little postoperative reaction. That the patient died later from an unexpected complication was a terrible blow to him. His passing has left a terrific void for those of us who have worked with him these many years. There is nothing which can be said about him which will in any way overemphasize his ambition, his honesty, and his straightforwardness."

EDWIN N. MILLER.



Howard L. Beye
1886-1936

Wharton; yet in the book, he gives no definition whatever of minor surgery. Furthermore, the last edition included fractures and dislocations, ligation of arteries, amputations, excisions, operations on nerves, removal of the vermiform appendix, lithotomy, cholecystostomy, and gastroenterostomy. If this be minor surgery, make the most of it!

The extensive treatise of Foote, with its 752 pages, shows a better spirit, in that the reader is now and then referred to textbooks on "major surgery." Its contents are carefully chosen. But the author does not tell us what minor surgery is.

Of the newest books, one (1935) discusses fracture of the skull; surgery of the nasopharynx, neck, jaws, and chest, with directions for operation in such conditions; diseases of the male and the female genital organs and of the extremities. Neither the eye nor the abdominal cavity are considered; hernia is described in detail. How much of this is major surgery?

A book (1935) of almost a thousand pages, which has gone through three editions, follows about the same table of contents as the work mentioned above. In the preface to the first edition (1929), the subject is defined as follows: "Minor surgery is the surgery which has a low mortality; which requires but few assistants; which generally is done in the hospital out-patient department or in the office. It includes the large majority of surgical cases; the everyday surgical conditions. *All minor surgery potentially is major surgery; often a distinction cannot be made.*"* Without disparaging the methods of treating the subjects or the value of the volume as a book of instruction (it is really an excellent and thorough treatise), objection must be made to the title.

Moreover, the definition will not hold water. Most all our surgical operations have a low mortality; many can be done with "but few assistants;" some must be done, even so-called major operations, as emergencies in hospital dispensaries and in the office. If minor surgery "includes the large majority of surgical cases," where do our major surgical cases come in? Finally, the author admits that "often a distinction cannot be made," because "all minor surgery is potentially major surgery." It is unfortunate that one should attempt to make the distinction.

To show my admiration for this author as a teacher and writer, I have endorsed the larger work (*Text Book of Surgery*, 1936), so ably edited by him, and regard it as the best book of its kind now extant. His book on *Minor Surgery* might be considered as the first volume of a combined work. The truth is, it requires much more knowledge and skill to perform many operations customarily classed under the head

*The italics are Dr. Royster's.

Editorials

What Is Minor Surgery?

WHEN it is remembered that principles are to guide us in surgical practice and that success in applying these requires always discriminating judgment and a certain aptitude, it seems useless to create a division of surgery into major and minor—or, rather, to set apart so-called minor surgery as a special department. But this artificial division has come about in some way and has gradually assumed a popular position without, it is feared, a good reason for its existence. To seek a proper definition of minor surgery, to point out, if possible, its boundary lines, to call attention to the misconceptions and dangers which may arise from regarding it as a separate branch of surgery—these appear to be pertinent objects.

One looks in vain for a definition of minor surgery which really defines. Search of textbooks and other literature shows a hopeless lack of uniformity, even of subjects embraced under the term. The definition given by Gross in 1882, which is the clearest to be found at that period, differs widely from the modern meaning. He calls minor surgery “an account of some of the more common instruments used in surgery, of the mode of making incisions, or of performing the elementary operations, the establishment of issues, the introduction of the seton, the application of the canter, bleeding, and the art of bandaging and dressing.” Besides these subjects, some of which are now obsolete, Gross discusses in the same chapter aspiration, skin and sponge grafting, transfusion of blood, hypodermic injections, vaccination, counterirritation, antiseptics, electricity, and massage. John Ashhurst (1889) has about the same subjects in his chapter on minor surgery. So does the *American Text Book of Surgery* (1892), which adds remarks on the clinical thermometer, heat and cold, adhesive plaster, and collodion. How different from the more recent conceptions of minor surgery!

Of the newest books on surgery in general, practically none contains a specific reference to, or has a chapter treating of, this subject. There are, however, several special works on minor surgery, small and large. It is interesting to compare the contents of these volumes with the very different ideas on the subject which existed even twenty years ago. Most of the works on minor surgery published as late as forty years ago were largely taken up with bandaging. One of the oldest is by

The strangest feature of the minor surgery propaganda is that such a division has no counterpart in other branches of medicine. We have heard nothing of minor medicine, minor obstetrics, minor neurology. Why not separate the big from the little things in these specialties? The wave has struck the diseases of women, and there has resulted the term, "medical" gynecology—whatever that may mean. These dissociations are not for the clearing up of the subject; rather they tend to the confusion of it.

When all is said and done, the question of what shall be considered as minor surgery is a matter of individual opinion. What one would regard as properly included under this arbitrarily erected department of surgery, another might consider as belonging to the larger subject alone. Such disagreements were manifest on asking the question of many professional associates, the replies varying from those who thought minor surgery to be that which was done without a general anesthetic, up to those who classed it as the performance only of those operations which are not per se dangerous to life. Most of us cannot define the subject to our own satisfaction, much less to that of others. It is not necessary to define it, or to set its boundaries, if we shall here apply the precept furnished by two important truths: the greater includes the lesser, and a chain is no stronger than its weakest link.

—*Hubert A. Royster, A.B., M.D.*
Raleigh, N. C.

of minor surgery (plastic operations, for example) than it does to execute certain procedures listed by some of our institutions as major surgery.

Now, the question naturally arises, where is the dividing line? Where does minor surgery end and major surgery begin? Or, if you please, where is the field of the term, major surgery, and who will essay a definition of that? If there is a major and a minor surgery, should there not be a superlative degree—a supreme surgery? The careless regard for terms, the tendency of authors and teachers to neglect what they would consider the smaller matters, and the encroachments of textbooks of minor surgery, together with hazy and diverse ideas in the minds of individuals, have served to render the classification difficult or even impossible. Indeed, it appears that the only proper basis for distinction between a minor and a major surgical operation depends upon the one who does it. A definition might be made as follows: *Minor surgery is that part of surgical practice which is done by the "minor surgeon."* The "major surgeon" also does what is included under minor surgery, though refusing to call it by that name; but the "minor surgeon" does not and should not do major surgery. Herein lies the danger. There is hardly a so-called minor operation which may not become a major one at any moment, and the more "minor" the surgeon, the more "major" the operation will become before he is through with it. The experienced surgeon does not try to locate the line of demarcation.

Curettage, an operation for hemorrhoids, aspiration for empyema, and the open treatment of fractures and dislocations will be undertaken by those who would not think of performing an abdominal section, the resection of a rib, or the formal ligation of an artery. And yet, in each of the operations first mentioned, there is the possibility of having to do one of those operations last named. Equal skill is required for both these classes of operating, but in the latter there are elements of risk, immediate and remote, which deter the average man from attempting what are called major operations. It is sometimes a matter of "nerve," and "nerve" means simply knowing what you are doing. In surgery, familiarity breeds repose.

It is by no means contended that the general practitioner should not do surgery; it is even urged that he do more and more, so that he may become proficient in that which falls to his lot, and not shirk his responsibilities. He should, however, understand deeply that the study of surgical principles is his duty, that surgery is the same wherever it is needed, that none of it is minor, and that all of it is surgery. Let him tune his judgment to his conscience, realize his limitations (as everyone must), and do surgery, not minor surgery.

Encouraging series of such cases have been reported by Gross and Sachs,²⁰⁰ Jelsma and Spurling,²⁰¹ and Penfield and Cone.^{202, 203} The last named authors attach great importance to the preservation of the sac as a means of preventing the subsequent development of the hydrocephalus which frequently follows these operations.

It is convenient to include in this section the great groups of cases of spasticity, athetosis, and related disorders, although, of course, many of these are not congenital, and, indeed, their etiology is often a matter of controversy. They have in common, however, the fact that all are disorders of the mechanism of movement.*

Little or no progress has been made in the treatment of the purely spastic disorders (e.g., Little's disease), although it is well to remember that Royle's pioneering sympathetic ramisections,^{209, 210} undertaken for the treatment of spasticity, helped to popularize a great new field of neurosurgery (cf. Section X). Further, some of these distressing cases probably result from birth injuries and may be prevented by prompt treatment immediately after birth (Munro²¹¹).

On the other hand, interest in the surgical relief of athetosis and the dystonias has been reawakened by recent neurophysiologic discoveries (Section I, frontal lobe). In 1932, Bucy and Buchanan²¹² reported resection of portions of the premotor and motor cortex for athetosis of one arm, with complete cessation of the athetoid movements. Sachs,²¹³ in 1935, reported three cases of athetosis treated by "subpial resection of the cortex," an operation originally employed for the same purpose by Horsley²¹⁴ in 1909. From Sachs' description, it seems probable that portions of both motor and premotor areas were included in the tissue removed. The results were very satisfactory. A case having a resection confined to the premotor area by Pileher²¹⁵ had a recurrence of athetoid movements several weeks after the almost immediate return of voluntary motion.

Meantime, Putnam²¹⁶ devised an operation for athetosis which consisted of section of the anterior or anterior and lateral extrapyramidal tracts high in the spinal cord. In four cases (two of postencephalitic athetosis and two of familial dystonia musculorum), considerable improvement resulted, while in two cases of paralysis agitans, slight improvement occurred in only one. Oldberg²¹⁷ has used a similar operation for athetosis with satisfactory results in some cases.

Spasmodic (or spastic) torticollis is another disorder of movement whose somatic etiologic aspects bring it into the group under discussion. However, in almost all, if not all, cases, there is an additional psychomotor element which plays a large part in its symptomatology as well as in the therapeutic results. Space does not permit a discussion of this

*It seems probable on experimental and clinical grounds that the lesions of all of the ameyetatic disorders involve to a greater or lesser extent the extrapyramidal motor system (cf. Penfield,^{218, 219} Jahanshahi,²²⁰ the papers of Fulton and his associates presented in Section I, and the papers cited in the following paragraph). This hypothesis, however, must not be accepted as conclusively proved (Wilson^{221, 222}).

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

RECENT ADVANCES IN NEUROSURGERY

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Part II*

V. CONGENITAL DISORDERS AND THE SPASTIC STATES

THE disorders to be discussed in this section have long been a *bête noir* to the neurosurgeon, and though recent progress gives promise of improvement, they are still among his most difficult problems.

Since the beginnings of medicine, the distressing problem of hydrocephalus has defied solution (cf. Weed,¹⁸⁷ and Cushing¹⁸⁸). Until recent years, most operations designed for the relief of the "communicating" type had as their aim the release of dammed-up cerebrospinal fluid through some type of fistula, under the skin, into the retroperitoneal tissues or into a ureter. These early methods have been discussed in a paper by Davidoff¹⁸⁹ whose ingenious experimental skin-tube operation has not apparently been given a clinical trial. More recently, surgical efforts have been directed toward diminishing the production of cerebrospinal fluid by removal of the choroid plexuses from the lateral ventricles. This may be done through a small cortical incision (Dandy¹⁹⁰). The ventriculoscopy approach originally employed by Dandy,¹⁹¹ and Mixter¹⁹² has been used recently by Putnam,^{193, 194} and Searff¹⁹⁵ for electrocoagulation of the choroid plexus, with very satisfactory results.

On the other hand, the "obstructive" type of hydrocephalus (i.e., the type in which the obstruction lies within the ventricular system or at its outlet) may be treated either by attacking the obstruction directly (Dandy^{196, 197}), or by providing a new cerebrospinal fluid outlet through the floor of the third ventricle (Dandy,^{190, 198} Mixter¹⁹²).

It is important to remember that any operation for hydrocephalus must be undertaken before extensive cerebral damage resulting from prolonged compression has occurred.

A somewhat less gloomy picture is presented by the plastic operations for spina bifida and cranium bifidum. These congenital bony defects allow the protrusion of meningeal sacs containing cerebrospinal fluid with or without portions of the spinal cord, cauda equina, or brain.

*Part I of this paper appeared in the January issue of SURGERY.

†In 1909, Von Bramann¹⁹⁹ performed puncture of the corpus callosum for the same purpose, but the method has met with little success.

from the subarachnoid space; Munro,²³⁴ reporting 1,494 cases, believes this the most effective treatment and has repeatedly insisted upon its superiority.^{235, 236}

On the other hand, there is a considerable weight of opinion opposing both of these therapeutic methods. On clinical grounds, Sachs^{237, 238} condemns spinal puncture as too dangerous, and the method is also opposed by Coleman,²³⁹ and Dandy.²⁴⁰ The latter also feels that the use of hypertonic solutions is unwise²⁴¹ and believes that subtemporal decompression should be employed in many cases. Experimentally, Sprong²⁴² has shown that the rate of disappearance of blood in the cerebrospinal fluid is not affected by withdrawal of fluid, and Masserman's²⁴³⁻²⁴⁷ studies indicate that the rapid reduction of cerebrospinal fluid pressure by either intravenous injection of hypertonic solutions or lumbar puncture is likely to be followed by a secondary rise in pressure beyond the original level. This evidence is in confirmation of the previous observations of Haug.²⁴⁸ Recently hypertonic solutions of sucrose have been investigated (Bullock, Gregerson, and Kinney,²⁴⁹ and Masserman²⁵⁰ and give promise of being more satisfactory than dextrose.

This important controversy has been reviewed in a recent comprehensive paper by Lehman and Parker,²⁵¹ who point out how little is really known regarding the mechanism of the changes following head trauma. In a valuable experimental study, the same authors²⁵² have shown that the increased pressure following replacement of cerebrospinal fluid by blood is probably the result of the increased osmotic pressure of the cerebrospinal fluid. Considerable doubt is thrown upon the existence of "traumatic cerebral edema" (i.e., increased tissue fluid) by the experiments of Pileher,²⁵³ and the postmortem observations of Connors and Wright.²⁵⁴

The literature on wounds of the brain has been recently reviewed by Pileher,²⁵⁵ whose experimental study demonstrated the dangers of retention of foreign bodies, contamination of the ventricles, and failure to treat cerebral wounds promptly. An excellent clinical paper on compound fracture of the skull has been published by Munro,²⁵⁶ and Naffziger and Glaser²⁵⁷ have studied depressed fractures in rabbits. The histologic aspects of head injuries have been extensively studied by Rand and Courville,²⁵⁸⁻²⁶² and others (cf. Sections IV and IX).

Among the complications of head injuries, subdural hematoma has received considerable attention. Until very recently, these expanding lesions have been thought to increase in size by continuing venous bleeding (Putnam and Cushing,²⁶³ Keegan,²⁶⁴ Leary²⁶⁵). However, McKenzie,²⁶⁶ and Gardner²⁶⁷ believe that the hematoma sac acts as a dialyzing membrane, permitting fluid to be drawn into the sac by osmotic pressure, and a careful study by Munro and Merritt²⁶⁸ seems to confirm this opinion. In 1932, McKenzie,²⁶⁶ and Fleming and Jones²⁶⁹ advised evacuation of the hematoma sac, rather than the more extensive osteo-

interesting phase of the subject. The reader is referred to the papers of Foerster,²⁰⁴ Hassin,²¹⁸ Grinker and Walker,²¹⁹ and those presently to be cited.

The early operative treatment of spasmodic torticollis was directed locally toward the sternocleidomastoid and associated muscles or the accessory nerves. It was gradually realized, however, that the deeper and more posterior muscles of the neck were involved, and extravertebral section of the upper spinal nerves was then advocated. Keen²²⁰ first performed this operation in 1891, and there were no further innovations until 1924, when McKenzie²²¹ reported section of the upper three cervical anterior and posterior roots and spinal accessory nerves intradurally, on one side, by Cushing. The patient was greatly improved. McKenzie expressed the opinion that the anterior roots could probably be spared without impairing the result. Foerster²²² had performed essentially the same operation four times in 1926 and, in 1929, he²²³ advocated section of only the posterior roots.

Finney and Hughson²²⁴ first realized that the disease is always actually or potentially bilateral and performed extravertebral section of the first three cervical nerves on both sides, with improvement in all but three of thirty-two cases (1925). The operations of Frazier,^{225, 226} and Dandy,²²⁷ both introduced in 1930, differ in that the former advocates bilateral section of the posterior roots of the first three cervical nerves, while the latter at first advised section of both anterior and posterior roots, but subsequently²²⁸ of only the anterior roots of the same nerves. The two operations probably produce equally satisfactory results, and the choice depends upon whether one prefers the anesthesia or the motor paralysis (for which the unparalyzed muscles soon largely compensate).

VI. INJURIES AND INFLAMMATIONS

Injuries of the head and spine grow more numerous each year with the increase in accidents resulting from rapid automobile travel, and they constitute an increasingly common problem for general practitioner and neurosurgeon alike. Many important contributions to the subject have been made, but there is as yet no unanimity of opinion regarding the therapy of head injuries.

Following the demonstration by Weed and his associates,²²⁹⁻²³² in 1919 and 1921, of the reduction in cerebrospinal fluid pressure and in the bulk of the brain which follows the intravenous administration of hypertonic solutions, the use of these solutions and of other "dehydrating" methods has been widely advocated. The chief exponent of the dehydration therapy has been Temple Fay, who has written numerous papers on the subject. These are summarized in a recent publication.²³³

Another widely used method of treatment is that of frequent lumbar punctures for the relief of cerebral compression and the removal of blood

of headache. The third opinion, that of McKenzie,³⁰⁵ is that such cases should be given an "internal decompression" by removal of a portion of the tumor and should be spared the unsightly hernia and useless prolongation of life produced by subtemporal decompression.

On the other hand, the more benign gliomas (especially astrocytomas) should be radically treated by wide extirpation, lobectomy, or removal of the mural nodules of astrocytomatous cysts (Elsberg,³⁰⁶ Frazier²⁹⁰).

Excellent general articles on brain tumors and pituitary tumors by McLéan^{307, 308} have just appeared in Bumke and Foerster's "Handbuch der Neurologie," and similar papers have been published in recent years by Foerster,³⁰⁹ and Adson,³¹⁰ in addition to the texts and sections in systems of surgery to be mentioned in Section XI.

The results of operations for intracranial tumors have been brilliantly portrayed in several publications from Cushing's clinic. His statistical study of the operative results in over two thousand classified tumors,³¹¹ with a total operative mortality of 11.9 per cent, ranks as a monument to the progress of neurosurgery. Similarly, the follow-up studies of Cairns,^{312, 313} and Van Wagenen³¹⁴ have proved the ultimate usefulness of tumor removal.

The surgery of spinal cord tumors has long been well established. The sensory and motor "levels," with or without nerve root pain and bladder and bowel disturbances, the Queckenstedt test, the increased protein content of the spinal fluid (and its occasional xanthochromic color and spontaneous coagulation—the Froin syndrome), and the localization by injection of iodized oil, all combined to make the danger of incorrect diagnosis relatively small in most cases. Similarly, the treatment, especially of extramedullary tumors, is a satisfactory phase of neurosurgery. Numerous valuable papers, however, have appeared in recent years.

Harkins³¹⁵ has reviewed the still controversial question of the use of iodized oil and has pointed out its potentially harmful effects, but he confirms the generally accepted opinion (cf. Elsberg³¹⁶) that it is indispensable in the diagnosis of otherwise unlocalizable tumors. Attention has recently been called to the spinal cord compression produced by rupture of the intervertebral disc with herniation into the canal by Peet and Echols,³¹⁷ Mixter and Barr,³¹⁸ Mixter and Ayer,³¹⁹ and Love and Adson.³²⁰ It is now believed that many of the lesions formerly thought to be enchondromas were of this type. Elsberg, long a leader in the field of cord tumors, has continued to contribute to the subject,^{316, 321, 322} and excellent general articles have been published by Ayer,³²³ Spurling and Mayfield,³²⁴ Learmonth,³²⁵ Adelstein and Patterson,³²⁶ Rogers,³²⁷ Tannaki,³²⁸ Grant,³²⁹ and Kernohan, Woltman, and Adson,³³⁰ among many others.

Irradiation therapy of the tumors of the nervous system and particularly of the gliomas has been extensively studied in recent years

plastic exploration formerly employed. Furlow²⁷⁰ believes this method is applicable only in selected cases, an opinion previously expressed by Rand.²⁷¹

In this connection should be mentioned the important operative treatment of spontaneous cerebral hemorrhage, originally carried out by Cushing,²⁷² and Russell and Sargent²⁷³ and recently revived by Penfield,²⁷⁴ and Craig and Adson.²⁷⁵ When employed in selected cases, the evacuation of the clot has been found to be a lifesaving measure.

Three important contributions to the treatment of spinal injuries are the traction-manipulation reduction of dislocations of the cervical spine by Taylor,²⁷⁶ and Brookes,²⁷⁷ the skeletal traction of Crutchfield,²⁷⁸ and McKenzie,²⁷⁹ and the method of tidal drainage of the bladder devised by Munro.²⁸⁰

Kahn²⁸¹ has had very satisfactory results in treating brain abscesses by allowing their spontaneous extrusion through an overlying skull and dural defect, and Fincher²⁸² has reported success with very radical bone removal for osteomyelitis of the skull. The rarity of successful open drainage of pyogenic meningitis (Ruttin,²⁸³ Walker and Bucy²⁸⁴) emphasizes the discouraging status of the treatment of infectious of the central nervous system.

VII. NEOPLASMS

Advances in our knowledge of the diagnosis and treatment of brain tumors have come largely through studies of large series of cases. Many of these were referred to in the section on neuropathology. Notable among numerous others are a series of studies of the meningiomas as they occur in various locations by Elsberg and his associates,²⁸⁵⁻²⁸⁷ and Cushing and Eisenhardt;²⁸⁸ of frontal lobe tumors by Voris, Adson, and Moersch,²⁸⁹ Frazier,²⁹⁰ Sachs,²⁹¹ Baruk,²⁹² Vincent,²⁹³ and Kolodny;²⁹⁴ of intraventricular tumors by Dandy;^{295, 296} of tumors producing unilateral exophthalmos by Elsberg, Hare, and Dyke,²⁹⁷ and Voris and Adson;²⁹⁸ of the acoustic tumors by Olivecrona;²⁹⁹ of the pontine gliomas by Bailey;³⁰⁰ and of the epidermoid tumors by Mahoney.³⁰¹

The difficult problem of the proper treatment of the infiltrating gliomas of the cerebrum has been a controversial subject, particularly as regards the glioblastomas, probably the most rapidly growing of all brain tumors. There are three widely different opinions. In selected cases, Dandy,³⁰² and Gardner³⁰³ have performed radical extirpation of entire right cerebral hemispheres (above the basal ganglia and thalamus). This formidable procedure, in addition to its operative risk, carries the certainty of leaving the patient a permanent invalid of greater or lesser degree, even if the tumor is completely eradicated. There are certainly few cases in whom it is justifiable.

Spurling,³⁰⁴ however, feels that all patients in whom a glioblastoma is found should have only a wide subtemporal decompression for relief

must be remembered that these methods may destroy the entire ganglion and the motor root, in addition to involving certain other dangers (cf. Putnam and Hampton³⁶³).

Section or injection of the trigeminal nerve afford equally complete relief for the pain of inoperable tumors in and about the mouth and face (Olivecrona,³⁶⁷ Stiasny,³⁵⁸ Putnam and Hampton,³⁶³ and many others).

Glossopharyngeal Neuralgia.—The ninth cranial nerve is the seat of an excruciating neuralgia similar to that of the trigeminus, and intolerable pain in its distribution also often results from inoperable neoplasms. Glossopharyngeal neuralgia was first described in 1920 by Sicard and Robineau.³⁶⁸ They sectioned the ninth nerve in the neck, an operation first performed a year earlier by Peet.³⁶⁹ In 1924 Adson³⁷⁰ suggested intracranial section, which was first done by Heath,³⁷¹ Fay,³⁷² and Davenport,³⁷³ for the pain of inoperable tumors. Dandy³⁷⁴ first treated true glossopharyngeal neuralgia by this method, and this operation is now the accepted procedure (Peet,³⁷⁵ Filatov,³⁷⁶ Keith³⁷⁷).

Ménière's Syndrome and Related Conditions.—It is convenient to consider here persistent vertigo and tinnitus, although it is by no means certain that they fall within the classification of cranial nerve ties. The etiology of Ménière's disease has been the subject of a number of recent observations. Some cases seem to be definitely allergic in character (Duke,³⁷⁸ Proetz,³⁷⁹ Urbach and Wilder³⁸⁰). On the other hand, Furstenberg, Lashmet, and Lathrop^{381, 382} have concluded, after careful study of a number of cases, that the condition is due to excessive retention of sodium and have obtained remarkable results by restriction of sodium in the diet. Foldes,³⁸³ and Bucy³⁸⁴ report confirmatory evidence.

Meantime, after a number of sporadic surgical efforts,* a satisfactory operative treatment for intractable cases was firmly established in 1928 by Dandy's³⁸⁹ report of nine cases of Ménière's disease successfully treated by section of the eighth nerve. The use of this method in a number of cases was soon reported by Coleman and Lyerly,³⁹⁰ and by Cairns and Brain.³⁹¹ In his first paper, Dandy suggested the possibility of division of only the vestibular portion of the nerve, and this was first done in 1931 by McKenzie,^{392, 393} shortly followed by Dandy.^{394, 395} The latter³⁹⁶ actually performed this differential section bilaterally in one case.

Peripheral and Visceral Pain.—The unbearable pain of inoperable pelvic carcinoma, amputation stump "neuroma," and similar painful conditions of irremediable cause has long been amenable to neurosurgical relief. Since its first use by Spiller and Martin,³⁹⁷ and Frazier³⁹⁸ at Spiller's suggestion, the operation of anterolateral chordotomy has been of proved value and has largely supplanted the older procedure of

*In 1902, Parry³⁸⁵ divided the eighth nerve, apparently for Ménière's disease. A similar attempt by Wallace and Marriage³⁸⁶ in 1904 was unsuccessful. Frazier performed the operation successfully in 1908 for aural vertigo³⁸⁷ and in 1913 for tinnitus.³⁸⁸

and has yielded some encouraging results. The first roentgen treatment of brain tumors was reported by Nordentoft,^{331, 332} and Christiansen³³³ in Denmark in 1918. These papers were followed by those of Pancoast³³⁴ in this country (1922), and Bremer, Coppez, and Sluys³³⁵ in France (1923). Pancoast first observed that certain cerebellar tumors showed great improvement, and, after the gliomas came to be histologically classified, it was recognized that the cerebellar medulloblastomas are the most radiosensitive of all the gliomas (Bailey, Sosman, and Van Dessel,³³⁶ Bailey³³⁷). The results with other tumor types are variable (Sachs, Rubinstein, and Arneson,³³⁸ Dyke,³³⁹ Olivecrona and Lys-holm³⁴⁰). Recently, Davis and Cutler³⁴¹ have employed the actual implantation of radium into glioblastomas, and it is possible that the method may prove of value. Alpers and Pancoast,³⁴² and Bailey and O'Connell³⁴³ have studied the effect of irradiation on brain tissue.

VIII. THE CRANIAL NERVE TICS AND THE RELIEF OF INTRACTABLE PAIN

When unbearable pain is of unknown or irremediable cause, symptomatic relief may usually be offered by interruption of the pain-bearing nerve pathways. This is the basis of one of the most satisfactory phases of neurosurgery.

Trigeminal Neuralgia.—With the introduction by Frazier³⁴⁴⁻³⁴⁷ of the differential section of the trigeminal root, which leaves corneal innervation and the motor root intact, the treatment of trigeminal neuralgia was placed upon a firm and rational basis, and this operation is still the procedure of choice of most neurosurgeons. Dandy,³⁴⁸ however, in 1925, began to do subtotal root sections in the posterior fossa, and has found this procedure satisfactory in a large number of cases.^{349, 350} Klemme,³⁵¹ who uses the temporal approach, states that very accurate subtotal division of the root can be obtained by splitting the ganglion from a point between the origin of the first and second divisions of the nerve backward into the posterior root. Preliminary alcohol injection of the peripheral divisions of the nerve, as a diagnostic measure and to familiarize the patient with the numbness which will follow posterior root section, is strongly advised by Grant,³⁵² and by Horrax and Poppen,³⁵³ but is opposed by Dandy,³⁵⁴ and others.

Following its introduction by Härtel,^{355, 356} the injection of the gasserian ganglion has been employed in Germany by Zander,³⁵⁷ Stiasny,³⁵⁸ and Sgalitzer and Brücke,³⁵⁹ in England by Harris,³⁶⁰ and in this country by Iger,^{361, 362} and Putnam and Hampton.^{363*} In 1933, Kirschner^{364, 365} advocated coagulation of the ganglion by means of an electrode enclosed within a long needle which is inserted through the foramen ovale. This method has also been employed by Zenker.³⁶⁶ It

*In a personal communication, Putnam states that he now prefers the electrocoagulation of Kirschner.

must be remembered that these methods may destroy the entire ganglion and the motor root, in addition to involving certain other dangers (cf. Putnam and Hampton³⁶³).

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posterior root section in this type of case. The results of chordotomy have been recently improved by the researches of Foerster,³⁹⁹ and Foerster and Gage.⁴⁰⁰ Other recent papers by Schüller⁴⁰¹ and Kahn⁴⁰² have reviewed the progress and results of the operation.

Another procedure for the relief of peripheral and visceral pain was introduced by Dogliotti.⁴⁰³ This consists of the intraspinal injection of minute amounts of alcohol. The method has been extensively employed in this country by Stern,^{404, 405} and recent papers by Abbott,⁴⁰⁶ Russell,⁴⁰⁷ and Adson⁴⁰⁸ indicate that it is of definite value in selected cases and in careful hands. Unless it is performed with the greatest care, there is a great risk of permanent motor damage (cf. Tureen and Gitt⁴⁰⁹).

The treatment of other painful conditions will be discussed in the section on sympathetic surgery.

IX. EPILEPSY

A consideration of true idiopathic epilepsy is not within the province of this paper. Able discussions of the subject have been published in recent years by Foerster,⁴¹⁰ Lennox and Cobb,^{411, 412} and Fay,⁴¹³ among others. With the progress of time, however, various types of convulsive seizures have been removed from the "idiopathic" group and shown to be amenable to specific therapeutic measures.

Since the time of Hughlings Jackson,⁴¹⁴ the focal motor attacks which bear his name have been recognized as due, in many cases, to tumor, scar, or other localized and often removable lesion.

Adequate surgical therapy of traumatic epilepsy has been given renewed impetus by the work of Del Rio Hortega and Penfield,⁴¹⁵ Foerster and Penfield,^{416, 417} Penfield,⁴¹⁸ and Wortis and McCulloch.⁴¹⁹ These investigators have thrown great light upon the structural and functional basis of the epileptic seizures and have emphasized the localizing importance of the nature of the attacks and of encephalography, and the therapeutic importance of radical extirpation of cortical scars. The recent literature on traumatic epilepsy has been reviewed by Spurling.⁴²⁰

Of great importance is an outgrowth of this work, dealing with focal epilepsy not due to demonstrable gross cerebral lesion. In a careful study of seventy-five cases of Jacksonian epilepsy, Penfield and Gage⁴²¹ have pointed out the localizing value of many types of aura and primary convulsive symptoms, even in cases in which the convulsions immediately become generalized. Furthermore, Penfield^{418, 422} has withdrawn many of these cases from the "idiopathic" group by proving their focal nature and has shown that the convulsions may be cured by appropriate cortical resection. The exact area involved is located at operation by careful electrical exploration of the cortex. Similarly, Sachs⁴²³ has performed cortical resection for Jacksonian epilepsy without gross lesion in eight

eases. It seems probable that more and more cases, hitherto considered idiopathic epilepsy, will be found to have a focal "trigger-zone," the removal of which will result in abolition of the convulsions.

The description of the syndrome of hyperinsulinism by Harris⁴²³⁻⁴²⁵ has shown that another large group of convulsive states is due to or exacerbated by hypoglycemia and is amenable to appropriate surgical or dietary therapy. (Cf. also Weil,⁴²⁶ Carr, et al.,⁴²⁷ Graham and Womack,⁴²⁸ Neilson and Eggleston,⁴²⁹ McGavern⁴³⁰.)

The study of all forms of epilepsy has recently been spurred by the organization of the International League Against Epilepsy, the American branch of which was organized in 1936 under the presidency of Dr. W. G. Lennox.

X. THE SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM

Modern sympathetic surgery had its beginning with the ramisection for spasticity performed in 1924 by Royle,^{209, 210} based on the experiments of Hunter.⁴³¹ True, the first cervicothoracic ganglionectomy was done in 1896 by Jonnesco⁴³² and the first periarterial sympathectomy by Jaboulay⁴³³ in 1899. The latter operation was extensively employed by Leriche,⁴³⁴⁻⁴³⁷ but met with little popularity, probably due to the demonstration by Kramer and Todd⁴³⁸ that the arterial nerve supply is distributed by main nerve trunks rather than along arterial trunks (cf. also Kuntz,⁴³⁹ and Ranson⁴⁴⁰).

Although Hunter's opinion is not now generally accepted (Ranson⁴⁴⁰), and Royle's operation has not proved effectual for the relief of spasticity, it, nevertheless, resulted in the mushroom-like growth of an enormous new field of surgery. The following year, the use of lumbar ganglionectomy for Raynaud's disease was reported by Diez,⁴⁴¹ and by Adson and Brown,⁴⁴² independently; Royle^{443, 444} promptly began to employ cervicothoracic trunk section (using an anterior approach) for Raynaud's disease of the upper extremities. A posterior approach with resection of the stellate and second thoracic ganglia was developed by Adson and Brown⁴⁴⁵ in 1929.*

The use of sympathetic resection for Raynaud's disease proved very satisfactory from the beginning (Adson,⁴⁴⁷ Adson and Brown,⁴⁴⁸ Spurling, Jelsma, and Rogers,⁴⁴⁹ Horton and Craig,⁴⁵⁰ Young⁴⁵¹), and almost immediately its use began to be advocated for a great many other conditions. As is the case in any new field, many of the attempts have proved fruitless, and others are as yet of uncertain value. In several types of disorder, however, in addition to Raynaud's disease, sympathetic surgery is of great value.

In 1927, Wade and Royle⁴⁵² reported a case of Hirschsprung's disease treated by left lumbar ramisection. Judd and Adson⁴⁵³ employed

*Adson and Brown credit Henry⁴⁴⁶ with using a similar operation for angina pectoris in 1924.

ganglionectomy the following year, and Rankin and Learmonth⁴⁵⁴ sectioned only the postganglionic fibers to the colon and rectum. It is now believed that the more radical procedure (Adson⁴⁵⁵) is necessary, and the results of this operation are strikingly successful.

Resection of the presacral nerve by Learmonth and Braasch,^{456, 457} and Adson⁴⁵⁸ for cord bladder and other paralytic vesical conditions has resulted in marked improvement, and the same operation gives great relief in selected cases of severe dysmenorrhea (Leriche,^{459*} Cotte and Dechaume,⁴⁶⁰ Adson and Masson,⁴⁶¹ Shaul,⁴⁶² Cannady and Bailey⁴⁶³). When employed for chronic interstitial cystitis, however, the results have by no means been uniformly good (Douglass,⁴⁶⁴ Van Dusen⁴⁶⁵). Adson, Craig, and Brown⁴⁶⁶ have reported the use of cervicothoracic sympathectomy for excessive sweating of the hands (hyperhidrosis) with excellent results, and relief was obtained in similar cases by Roberts,⁴⁶⁷ and Leriche and Frich.⁴⁶⁸

Controversies still continue regarding the surgical treatment of polyarthritis, angina pectoris, and essential hypertension.

Any improvement which follows sympathetic surgery for polyarthritis (first reported by Rowntree and Adson⁴⁶⁹) can result only from an increase in the circulation of the affected joints, and only patients in whom the pain is relieved by local or bodily increase in temperature should be so treated. With careful selection of cases, favorable results may be expected in some instances (Rowntree, Adson, and Hench,⁴⁷⁰ Hench and Craig,⁴⁷¹ Spurling and Jelsma,⁴⁷² Young,⁴⁷³ Flothow⁴⁷⁴).

Angina pectoris has been treated by various operations upon the sympathetic nerves since the first operation for this purpose by Jonnesco⁴⁷⁵ in 1906. Relief of pain has been often reported, but, at best, the results are variable, the mortality rate high, and the contraindications numerous (cf. Leriche and Fontaine,⁴⁷⁶⁻⁴⁷⁸ Cutler,^{479, 480} Coffee, Brown, and Humber,⁴⁸¹⁻⁴⁸³ Adson,⁴⁸⁵ Danielopolu,⁴⁸⁴ MacKenzie,⁴⁸⁵ Hofer⁴⁸⁶). In 1925, Mandl⁴⁸⁷ reported temporary relief of angina pectoris by the paravertebral injection of procaine, and the following year alcohol was used for the same purpose by Swetlow.⁴⁸⁸ This procedure has since been used extensively by White^{489, 490} with success in most cases. Empirically, paravertebral alcohol injection gives better results than any but the most radical operations, while being almost entirely free of the dangers of extensive surgical procedures. Scientifically, it has been given a sound rational basis by the recent experiments of White, Garrey, and Atkins,⁴⁹¹ who have shown that all cardiac pain is transmitted over the sympathetic nerves through the upper five thoracic posterior roots. This work also establishes the rationale of the multiple posterior root sections employed by Davis.⁴⁹² White and his associates are careful to warn, however, that even paravertebral alcohol block should be used only in selected patients in whom the pain is intolerable and unresponsive to medical treatment.

*Leriche employed only periarterial sympathectomy of the great pelvic vessels.

If essential hypertension, without primary renal or cardiac disease, be characterized by a widespread arterial constriction mediated through the sympathetic vasoconstrictor nerves, then a vasoconstrictor paralysis of a large cross-section area of the arterial bed should result in an improvement in the elevated blood pressure. The renal and suprarenal nerve supply should also be abolished or diminished, thus producing further improvement. This is the basis of several operations recently proposed for this distressing condition. Adson and Brown,^{493, 494} and Page and Heuer^{495, 496} sectioned the anterior spinal roots bilaterally from the sixth thoracic to the second lumbar, inclusive. Section of the splanchnic nerves subdiaphragmatically by Craig and Brown,⁴⁹⁷ and supradiaphragmatically by Peet^{498, 499} has been employed, and Adson^{455, 500} has recently added partial suprarenalectomy to Craig's operation. Varying degrees of success have been reported with these operations, but it is yet too early to be certain of their ultimate effects. Allen, Lundy, and Adson⁵⁰¹ have stated that the *immediate* effects may be pre-operatively predicted by observing the effects of pentothal anesthesia on the blood pressure. Recent experiments by Prinzmetal and Wilson⁵⁰² have thrown some doubt on the primary premise stated above by showing that the vasoconstriction may not be of a central neurogenic nature. Time and further investigation should clarify this question.

Operations on the sympathetic nervous system have been proposed or employed for scleroderma (Brown, O'Leary, and Adson^{455, 503}), retinitis pigmentosa (Royle,⁵⁰⁴ McDonald and McKenzie⁵⁰⁵), and certain types of headache (Love and Adson⁵⁰⁶). Excellent general discussions of sympathetic surgery have been published by Young,⁵⁰⁷ Adson,⁴⁵⁵ Leriche and Fontaine,⁵⁰⁸ Livingston,⁵⁰⁹ and Spurling.⁵¹⁰

XI. THE TEACHING OF NEUROSURGERY

In a telegram to the Harvey Cushing Society, meeting in Rochester, Minnesota, in 1936, Dr. Cushing said, ". . . [I] venture again to remind the Society in the words of Leonardo that it is a mediocre pupil who does not excel his master." Though to do so may be deemed almost impossible, it is no less a tribute to Dr. Cushing and his contemporaries and older pupils that neurosurgery has attained its present status as a recognized and essential specialty, skillfully and intelligently practiced in all of the university hospitals and most of the larger cities of this and other countries.

This extraordinary growth must be attributed in large measure to the personal teaching and influence of relatively few great pioneers in the field. Neurosurgical centers have arisen in Boston and Breslau, in Philadelphia and Stockholm, in Montreal, Baltimore, New York, St. Louis, Rochester, Chicago, San Francisco, and elsewhere, to which young men gravitate in ever increasing numbers for special training in this field. The establishment of great institutes of neurology and of closer

relationship between laboratories of physiology and pathology and their respective clinics have contributed greatly to the progress of neurosurgery. A growing academic tendency has appeared, particularly in Boston, Chicago and Montreal, to group neurology and neurosurgery together, with neuropsychiatry as a separate field. Such a logical arrangement affords improved facilities for the teaching of students and prospective neurosurgeons alike.

Concomitant with the invaluable personal teaching has come the publication of numerous important texts and sections in systems of surgery. Among recent publications of this kind may be mentioned those of Sachs,⁵¹¹ Bailey,⁵¹² Spurling,⁵¹³ Dandy,¹⁹⁰ Horrax,⁵¹⁴ Adson,⁵¹⁰ Peet,⁵¹⁵ Mixer,⁵¹⁶ Elsberg,⁵¹⁷ and Stookey.⁵¹⁸

Neurosurgery climbs on, then, to ever greater heights over "the clustered shoulders" of all those mentioned all too briefly in this limited summary and of many others as well. Much progress has been made, but greater discoveries await us.

Kind friends, too numerous to list here, have been of great assistance by sending reprints and valuable suggestions. To all of them the author is grateful, but for errors of omission and commission he alone is responsible.

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Review of Recent Meetings

REVIEW OF THE TWENTY-SECOND ANNUAL MEETING OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA, CINCINNATI, OHIO, NOVEMBER 30 TO DECEMBER 4, 1936

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(From the Department of Radiology, University of Minnesota)

THE annual meeting of the Radiological Society of North America produced a number of papers of interest to surgeons. Only those contributions which were outstanding or particularly interesting will be reviewed here. In the first session Dr. Oscar Lipschultz, of Minneapolis, presented a paper on Late Results in Traumatically Displaced Epiphyses. He reported the end-results in a large series of cases in which reexamination was made from eighteen months to eight years after an injury with displacement or fracture of an epiphysis. Comparison of the length of the injured bone with the normal side and with normal controls was made, and there were observations as to the presence of deformity or other growth disturbance. It appears that trauma to the epiphysis rarely results in functional deformity or disability. There may be some shortening or, in a few cases, some lengthening of the involved extremity, but this is usually insufficient to produce any disturbance of function. Furthermore, it would appear from his results that the degree of reduction of the displaced epiphysis has relatively little relationship to the end-results.

A very illuminating paper by Dr. Henry Snure and Dr. George D. Maner, of Los Angeles, was presented on Roentgen Ray Evidence of Metastatic Malignancy in Bones. Dr. Snure pointed out that in many instances good roentgenograms fail to reveal evidences of metastatic malignancy in bones in which metastases were later found at autopsy. Experimental work indicated that small erosions of the medullary canal could be demonstrated only with great difficulty and frequently not at all in the roentgenogram. Changes in the cortex of the bone were much more obvious. Metastases to the spine are particularly likely to be overlooked. The negative roentgen diagnosis, therefore, is not always indicative of the absence of metastases.

The Incidence and Classification of Hiatus Hernias was discussed by Dr. Maurice S. Dwyer, of Seattle. He brought out the importance of the recognition of these hernias, that they are much more frequent than has generally been considered; he described in some detail the various classifications.

Dr. Ray Carter, of Los Angeles, presented a paper on Noncarcinomatous Tumors of the Stomach, in which he demonstrated that sarcomas of various types, neurofibromas, and numerous benign tumors, all could be demonstrated by roentgen examination as occurring in the stomach. These noncarcinomatous tumors are probably more frequent than has previously been supposed and their recognition is of great importance.

Experimental work on The Rate of Emptying of the Gallbladder in Patients With Gastric and Duodenal Ulcer was reported by Dr. Edward A. Boyden, of Minne-

apolis. Dr. Boyden presented data to show the effect of pregnancy, carcinoma, gastric ulcer, and duodenal ulcer on the rate of emptying of the gallbladder after a standard meal of egg yolks and cream. The curves, which can be plotted from careful measurements of the emptying gallbladder, indicate clearly that both gastric and duodenal ulcers cause increased rapidity of emptying of the gallbladder, while pregnancy causes a marked delay in emptying. The exact mechanism of this effect of ulcer is not entirely clear, but it is possible that the tendency for a preliminary rush of the meal from the stomach into the duodenum, in cases of ulcer, may account for the increased rapidity of emptying of the gallbladder.

Dr. Edward W. Rowe, of Lincoln, Neb., presented a paper on **Primary Tumors of the Small Intestine**, reporting in great detail the findings in eight cases, and calling attention to the importance of repeated examinations of the small intestine roentgenologically, for the demonstration of these tumors which are very often overlooked.

On December 2, there was presented a series of papers of considerable interest. **Carcinoma of the Bronchus** was presented by Dr. Lewis H. Clerf, of Philadelphia, who emphasized the importance of both roentgen and bronchoscopic examinations in patients suspected of carcinoma. He paid particular attention to the importance of wheeze as an early symptom and also called attention to the difficulties in bronchoscopic diagnosis of tumors of the upper lobe or of the peripheral bronchi. He directed attention to the fact that in the early stages of a bronchial carcinoma, obstructive emphysema might conceivably be produced, and that the observation of this in a roentgenogram might present a very important, early sign of carcinoma. Close cooperation between internist, roentgenologist, and bronchoscopist is absolutely necessary to achieve a diagnosis of bronchogenic carcinoma.

Roentgen Methods of Studying the Soft Tissue Structures of the Neck were discussed by Dr. W. Edward Chamberlain and Dr. Albert K. Merchant, of Philadelphia. They reviewed the work that had previously been done on the demonstration of the tissues of the neck, and showed clearly the importance of roentgen study particularly with relationship to tumors of the larynx. Paralysis of the vocal cords can readily be detected by fluoroscopic examination, while tumors extending into the larynx or into the pharynx, inflammatory processes, foreign bodies, and various other types of morbid anatomy can be quite clearly delineated if the proper technic is used. The paper was discussed by Dr. Brown and Dr. Iglauer, of the University of Cincinnati, who presented numerous cases to emphasize the importance of the roentgen examination of the neck.

Pulmonary Pneumocoele, Certain Considerations in Cystic Disease of the Lung was presented by Dr. Carlton B. Peirce and Dr. Paul R. Dirkse, of the University of Michigan. Dr. Peirce pointed out that not all cysts of the lung are necessarily congenital and that the designation of a cyst as congenital, because of the absence of a definite preceding history of disease, is not necessarily correct. He demonstrated clearly, by a number of cases, that inflammatory processes of the lungs in early childhood may cause stenosis of the bronchus; an air cyst may thus be produced in the lung and in many instances may remain permanently. In cases of this type, seen later in life, the tendency to diagnose this residual cyst as congenital in origin should be curbed. It is clearly possible to produce a pneumatocele as a result of almost any type of inflammatory process in the lung.

On December 3, a symposium on x-ray therapy was held. **Radiation Treatment of Malignancy of the Lip** was presented by Dr. Ira L. Kaplan, of New York. He detailed his observations on a series of 147 cases of carcinoma largely of advanced type. The factors which influence the mode of treatment are: (1) position and

size of lesion, (2) presence of ulceration or infection, (3) presence of gland extension, and (4) age of patient. Biopsy is always suggested. All cases have irradiation to the neck area. Heavy doses of x-rays are used, and this is increased when fixed nodes are present. The radium pack is preferred when it is available. The local lesion may be attacked by surgery, radium, x-ray, or a combination.

A paper on *A Study of Radium Technic in the Treatment of Carcinoma of the Rectum* was presented by Dr. Harry H. Bowing and Dr. Robert E. Fricke, of Rochester, Minn. Radium therapy of rectal carcinoma shows more divergence in methods of treatment than does the treatment of carcinoma elsewhere in the body. This is necessarily so, because of many factors peculiar to malignancy in this situation. Except when a colostomy has been performed, we are treating a part of the body which cannot be immobilized, but must continue its daily function during treatment. Even if a colostomy has been performed, we are treating a field which is always infected and cannot be rendered aseptic. The general state of health of the individual patient has an important bearing on the selection of methods of treatment; we are dealing with an advanced age group with shorter life expectancy, and a large number have concomitant serious diseases of other organs.

Dr. Hayes E. Martin, of New York, gave a paper on *Peroral X-radiation in the Treatment of Intraoral Cancers*. In many intraoral growths, protracted x-radiation is used as a part of the treatment. If given through the skin of the cheeks and neck, adequate dosage may be followed by some late degenerative changes in the skin, bone, or other deep tissues. At least a portion of these untoward effects may be avoided by the use of peroral portals in conjunction with the usual methods of treatment. The technic was described in detail, the tube being placed within the mouth and x-rays given with a shock-proof tube.

The question *Should the Method of Coutard Be Applied in All Cases of Cancer Treated by Roentgen Rays?* was discussed by Dr. W. Edward Chamberlain and Dr. Barton R. Young, of Philadelphia. It was emphasized that in certain cases the massive dose method was superior to the fractionated dose and that it might constitute a serious error to apply the Coutard method in certain cases. Individualization of cases is of great importance, and the routine use of the Coutard method is to be decried.

An important and original contribution *Studies on the Effects of Neutron Radiation* was presented by Dr. Robert Stone, of San Francisco. Dr. Stone and his associates administered $RnNa$ intravenously and intraductally in a case of aleucemic leukemia with enlarged lymph nodes. They made careful measurements of the radioactivity of the blood of the patient himself, and of the various excreta during a period of several days. The decay took place almost completely in sixty to eighty-four hours and the elimination during this period was less than 10 per cent. As much as 53 mc. eq. were given without any untoward effects and, likewise, with practically no therapeutic results. In the discussion, Dr. Robert Newell, of San Francisco, called attention to the radical difference in the effects of $RaNa$ as compared to $RnCl$. A dosage of the latter as small as 1/100 of that given by Dr. Stone produced severe—often disastrous—effects. The difference, no doubt, lies in the character of the decay, $RaCl$ giving off alpha rays, while $RnNa$ gives off beta rays.

A symposium on *Gastroscopy and Roentgenology in the Diagnosis of Diseases of the Stomach* was presented by Dr. Rudolph Schindler and Dr. Frederic Templeton, of Chicago; Dr. E. B. Benedict and Dr. Richard Schatzki, of Boston; and Dr. B. R. Kirklin, of Rochester, Minn. This was followed by an extensive discussion by authorities in these fields. There was general agreement among the

essayists as follows: gastroscopy should always be preceded by adequate roentgen examination of the stomach; with the flexible gastroscope, the procedure is not particularly dangerous, although accidental perforations may rarely occur; gastroscopy is chiefly valuable in the diagnosis of gastritis, hemorrhagic erosions of the gastric mucosa, very small polyps, very shallow gastric ulcers, and frequently be of value in the detection of larger gastric ulcers, of carcinoma, and other types of tumors, and in the differentiation of benign from malignant ulcers. Gastroscopy is supplemental to roentgenology in those cases wherein persistent symptoms are found but the roentgen examination is negative, and in those in which the roentgen findings are doubtful. Gastroscopy has sharp limitations, particularly as regards the pyloric portion and the fundus of the stomach. It is far superior to the roentgen examination in the diagnosis of gastritis.

The final session was given over to a number of topics. *Skeletal Anomalies and Industrial Injuries* were discussed by Dr. W. Warner Watkins, of Phoenix, Ariz. He demonstrated a large number of anatomic variations and anomalies which are familiar to the experienced roentgenologist, but which are often mistaken for fractures or other injuries by clinicians with little experience. Unfortunately their opinions as to the interpretation of roentgenograms may be fully accepted in the courts, with resultant miscarriages of justice.

A symposium on physics occupied the remainder of the program. In the main, this was highly technical. A paper on *The Biological Action of Neutron Rays* was presented by Dr. John H. Lawrence, of the University of California. They detailed experiments on mice comparing the effects of neutron rays and x-rays in the killing of the mice and in the destruction of mouse tumors. It appears that the ratio between the lethal dose and the tumor-killing dose of neutron rays is greater than a similar ratio of x-rays. This suggests the possibility that neutron rays have a greater specificity for tumors than x-rays. The work is as yet insufficiently developed to be conclusive.

Dr. Robert S. Stone and Dr. Paul C. Aebersold, of San Francisco, presented a paper on *Clinical Application of Physical Measurements of 200 kv. and 1,000 kv. X-rays*. They used a 200 kv. constant potential and a 1,000 kv. radio-frequency x-ray apparatus. The measurements of ionization on the surface and for depth dose indicated that 1,000 kv. x-rays were superior chiefly in very large fields as applied to unusually thick individuals. In such structures as the neck, for example, where penetration of the 1,000 kv. x-rays is very great, there is a disadvantage which nullifies the greater depth dose; namely, the use of several portals is greatly hampered by the effect on the skin on the side opposite the portal of entry. Considerable experience with both qualities of radiation does not yet indicate any extreme advantages in the higher voltage radiation.

THE FORTY-FIFTH CONGRESS OF THE FRENCH SURGICAL
ASSOCIATION, PARIS, OCTOBER 5 TO 10, 1936

JAMES C. WHITE, M.D., BOSTON, MASS.

(From the Massachusetts General Hospital.)

AN INTERESTING symposium was held on grafting ovaries; it was published in full in "La presse médicale," October 10, 1936.

M. Mocquot, of Paris, reported on the findings in animal experiments: In general, the results of homografts are not nearly as good as those following autografts. Although some promising physiologic responses have been achieved in grafting ovaries from another animal of the same species and similar age, they have been definitely less successful than reimplantation of the animal's own ovary after castration. Under these circumstances, evidence of ovulation and internal secretion has been observed over a three-year period. Grafting the ovarian tissue within the uterine cavity has been followed by successful impregnation.

Mocquot confirms Hirsted's law, that successful takes are more common in the complete absence of glandular secretion. He has found that massive grafts offer too small an area for adequate vascularization. On the other hand, multiple grafts in tiny fragments do not well resist the defense reactions of the organism. The best method seems to be to implant the ovary sectioned into two pieces (Pettinari). Grafts have been made in a great variety of places: in the parietal peritoneum and in the omentum, or within the tubes or the uterine cavity, in order to obtain the passage of ova; in the anterior chamber of the eye for direct observation; and in the muscles when internal secretion alone is to be obtained. Signs of regeneration have been observed at the end of a month with new formed follicles and corpora lutea. At the end of several months, the grafted tissue may appear nearly normal, but its bulk begins to diminish little by little. In guinea pigs some of the grafts have used up their follicular reserve at the end of three to four months, nearly always at the end of two to three years. Durable results are increasingly difficult to obtain as one ascends the phylogenetic scale.

M. Cotte, of Lyon, reported on his personal cases of ovarian grafts in women, and reviewed the results published in France and abroad: No lasting results have been seen in homografts taken from another woman and transplanted into one where castration has been followed by characteristic menopausal symptoms. Sippel, the surgeon who has had the greatest experience with this method, has concluded that ovarian homografts are always absorbed after a short period. Similarly, heterografts (from other species) are always destined to be absorbed, notwithstanding some of the reports published by Voronoff.

Good evidence, however, exists that autografts, made by reimplantation of healthy ovarian tissue at the time of operation, can be successful. Their use has two principal indications:

1. In young women whose tubes are hopelessly diseased and for whom salpingectomy is unavoidable, it is occasionally possible to graft a healthy ovary within the uterine cavity. It is much better to transplant the ovary with its pedicle intact than to attempt a free graft. Cotte reports 200 such procedures, followed by pregnancy in twenty-one instances, but a third of these terminated in miscarriage at the third or fourth month.

2. In cases of advanced pelvic inflammatory disease where a salpingo-oophorectomy must be done, Cotte discusses the value of implanting free grafts of small

bits of undiseased ovary. He states that in well-selected cases such grafts often prevent the symptoms of premature menopause which follow castration.

When employed with judgment in cases where conservative partial resection of the ovaries or salpingectomy is impossible, Cotte concludes that such grafts are worth while. This is particularly true when it is possible to preserve the uterus. In his personal statistics of 92 such cases, where portions of ovary were grafted in the omentum, menstruation was reestablished in 65 out of the 74 patients which were followed. This generally takes place at the end of three months, but in severe cases of pelvic inflammation, it may be delayed for seven months. Histologic examinations of the grafts have shown a reduction in the number of primordial follicles and often a cystic degeneration. As a result, the physiologic activity of such grafts cannot be expected to last as long as that of the normal ovary. Luteinization often occurs without rupture. Examinations of the uterine mucosa made by Bourg show perfectly normal evolution, which is the best test of the physiologic activity of the graft.

THE THIRD CONGRESS OF THE INTERNATIONAL SOCIETY OF ORTHOPEDIC SURGERY

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(From the Section on Orthopedic Surgery, The Mayo Clinic)

THE Third Congress of the International Society of Orthopedic Surgery met in Bologna and Rome, September 21 to 25, inclusive, with Professor Ombredanne, of Paris, as president of the Society. Professor Putti, of Bologna, was president of the Congress and as such did much to make a most impressive meeting for those who were privileged to attend.

Bologna is a particularly suitable place for such a meeting, for several reasons. In the first place, it is a city of considerable historic interest, dating back as it does to the pre-Christian era. In the second place, it is the site of one of the oldest universities in Europe. The beginnings of this university date back to the eleventh century, when student guilds existed. In the twelfth century the guilds were grouped together to form the university. At first law was the only subject taught, but later other faculties were added. As Professor Putti pointed out, as early as 1426 a lectureship "in dislocations and fractures of bones" was established. Bologna is also the site of the "Institute Rizzoli," which has been in existence for more than a hundred years as a surgical institution, and from which has emanated some orthopedic procedures of the greatest importance. It has been a leader in the development of modern orthopedic surgery. Finally, Bologna was particularly suitable for such a congress because of the presence there of Professor Putti, who is today one of the outstanding, if not the outstanding, orthopedic surgeons in the world. He has been a leader in this rapidly developing specialty and has made several contributions of major importance to its literature. He is not only an excellent surgeon, but a teacher and leader as well, and because of these attributes and his facility with languages, he is certainly the outstanding member of the International Orthopedic Society. He was the originator of the idea of an International Orthopedic Society, and his presence in the leading rôle made the meeting highly successful.

The meeting opened with the inauguration of the Congress, and several officials of the government as well as of the university spoke. Professor Putti's presi-

dential address reviewed the development of orthopedic surgery and emphasized the conception of its scope, which originated with his predecessor, Alessandro Codivilla. "This conception," he said, "is synthetically expressed in the formula now universally accepted by which 'orthopaedic' is the synonym of surgery of the organs of movement." He further emphasized the importance of orthopedic surgery in the cure of increasing numbers of traumatic cases. The significance of this is emphasized by the fact that the Society later accepted Professor Putti's proposal to change its name from "The International Society of Orthopedic Surgery" to "The International Society of Orthopedic Surgery and Traumatology."

The clinical meetings followed the first day's meeting, and they were devoted to discussion of internal derangements of the knee. Several speakers presented different phases of the subject, one of the principal speakers being Mr. Harry Platt, of Manchester, who reported on a series of 762 cases of torn semilunar cartilage. The treatment in these cases has come to be fairly well standardized in the British Isles, where a great many such cases are seen. In our own country, treatment has followed along much the same lines. It was interesting to hear from some of the representatives of other countries the type of operative approach employed in these cases; some of them seemed rather radical.

The second clinical day was devoted to a discussion of the subject of Arthrosis in the Sequelae of Infantile Paralysis. The term "arthrosis" is one not often heard in this country but is apparently widely used in Europe; it means "bone block." The posterior bone block of Campbell has been widely accepted in American and in most European countries, but the Europeans have gone farther and produced bone block operations to stabilize the ankle in all of its four directions of movement, and the knee in the anterior as well as posterior movement. It may also be used in the treatment of joints of the upper extremity. It was difficult to evaluate the results of these operative procedures from the papers presented at the meeting. The posterior bone block of Campbell seems to be a procedure of recognized value. The use of bone block to stabilize other movements of those joints is at least being attempted in Europe, and probably more time should be given before a final evaluation of these procedures is made.

The third day in Bologna was given to the presentation of a variety of papers. One of the outstanding papers during this session was presented by M. Faldini, of Milan, on immediate subtrochanteric osteotomy in fractures of the neck of the femur. The form of his presentation set an example for international meetings, inasmuch as he illustrated the procedure with a few simple charts and then gave the substance of his talk in a very short discussion, first in Italian, and then in English, French, and German. Finally, he presented about ten elderly women, all of whom had undergone the operation with excellent results. Several other interesting papers were presented on this day, and during the afternoon the entire Congress moved on to Rome where the remainder of the papers were read, and where an inspection was made of the Orthopedic Clinic in Rome.

The social events were beautifully planned and executed, Bologna with her ancient palaces lending herself admirably to such an occasion. The president's dinner on the first evening was held at the Palazzo Podesta, a reception by the Municipality of Bologna at the Palazzo Comunale and a banquet of the Society at the Institute Rizzoli being the principal events.

Everyone came away with a great deal of satisfaction and all those who attended felt that the meeting had been of high quality and had set a standard for others in the future. The next congress of the Society was set for 1939. It is to be held in Berlin, with Professor Haglund as president of the Society and Professor Goelt as president of the Congress.

Book Reviews

Neurological Surgery. By Loyal Davis. Cloth. Pp. 429, with 174 illustrations. Philadelphia, 1936, Lea & Febiger. \$6.

This book should very well serve the purpose for which its preface says it was written, "to give to the practitioner of medicine easily assimilable facts which will aid him in giving his patient accurate and sound advice." This material, including all fields of neurologic surgery, has not been previously collected into a single volume. It is concise, but it includes the fundamental facts about each condition in well-arranged form. The chapter divisions and subdivisions are made in large bold-faced type with good spacing which makes the book much better as a reference work and more easily read if it is used as a textbook.

A valuable feature is the author's account of his experience which follows the general discussion of a lesion. As a rule the total number of cases observed is included, making it possible for the reader to estimate with what background of experience the author's opinions are weighted. Some of the most important references are given. The illustrations are excellent and the photography is good, but the plethysmographs in Chapter XI in the form in which they are given require too much effort on the part of the reader to be of value in a book of this kind.

A few errors in grammar occur in the text. The style for the most part is clear and direct in this excellent book.

Proctology. By Frank C. Yeomans. Second edition. Pp. 661, with 421 illustrations and 4 colored plates. New York, 1936, D. Appleton-Century Company, Inc. \$12.

He who undertakes the task of writing a general text must of necessity try to lend the impression of having an equal interest in all aspects of the subject matter. Rarely does he succeed in his endeavor. The field in which the author's richest experience lies beckons with an appeal which he cannot well conceal. For this lack of balance, the reader, however, is frequently well compensated by the more practical wisdom and mature judgments expressed in the sections of the author's special interest. Most texts written by a single author are likely to be beset with this sin. To this weakness, this book is no exception.

The chapters on the anatomy of the anal canal and rectum, diagnostic methods and preparation for operation, hemorrhoids, fissure, fistulas, and electrocoagulation and surgical treatment of rectal malignancies will be found particularly instructive. In the discussion of amebic dysentery, the author points out that isolation of the organisms is much more likely when swabs are made directly from the ulcers. This method would appear to have considerably more merit than the usual examination of the stool.

Many of the chapters contain historical matter of great interest and carefully selected bibliographic references. Pertinent tables and good illustrations help to clarify the text.

Surgeons who have had experience with operations for imperforation of the anal canal and rectum would not agree with the author's statement that if the rectal pouch cannot be found after a ten-minute perineal dissection, colostomy should be done. The author also is apparently unaware of the important paper of Wood Jones upon the delimitations of the rectum. The author's justification for counting nine out of ten operations for imperforation of the rectum successful when seven died within sixteen days of the time of operation would appear to require explanation. Whereas thirteen figures are employed to depict the variety of anatomic types of imperforation and their variants which may be encountered, the value of a roentgenogram in the inverted posture receives but mere mention, and this important

agency in deciding the order of magnitude of the operation necessary is not illustrated.

In the chapter on prolapse of the rectum, no mention is made in treatment of the Ekelhorn posterior rectal fixation, of the strangulation of the prolapsed bowel over a tube by ligatures or rubber bands, and of the Delorme and Whitehead procedures. Most surgeons would find the treatment of this subject matter incomplete without a discussion of these procedures.

In the chapter relating to intestinal obstructions arising in the rectum and pelvic colon, the author states that the time element precludes the employment of roentgenographic aids, thereby indicating how little experience he has had with the problem of acute obstruction of the pelvic colon. He also fails to point out the danger of perforation in obstruction of the pelvic colon. The matter of the management of such obstructions is given no adequate discussion here. The consideration of the management of carcinoma of the rectum is excellent. The author finds radium a helpful adjunct in the treatment of rectal malignancy.

This monograph, however, is a valuable and practical treatise which can be read with profit by anyone who deals with rectal diseases.

Minor Surgery. Edited by Frederick Christopher. Third edition. Cloth. Pp. 1030, with 709 illustrations. Philadelphia, W. B. Saunders Company. \$10.

That three editions of Christopher's *Minor Surgery* have been presented in seven years bespeaks a deserved popularity of this book. This text well supplements the crowded curriculum in the teaching of surgery in our medical schools, where as a general rule most of the time is spent on subjects of major importance.

In this third edition, the same excellent plan of the book is maintained, covering general topics in the first seven chapters and presenting a regional minor surgery in the remainder of the book.

That all minor surgery may be of major importance has been recognized, and the details of treatment are sufficiently comprehensive to help avoid many difficulties which often arise in the management of the apparently minor case.

In revision of the text, most of the verbatim references have been reduced to smaller print, making them more distinctive, as well as permitting the addition of a large amount of new material while adding but 132 pages to the book. Many new illustrations have been included to supplement the very excellent group in the previous editions.

In every chapter numerous additions of the results of recent studies have brought the entire subject matter up to date, giving us many new and useful methods of treatment in minor surgery.

The latest work on the process of wound healing is fully discussed. The ambulatory treatment of hernia by the injection method is well covered, although perhaps too briefly. A discussion of the Elliott treatment for chronic pelvic inflammations has been added. The Wangenstein suction apparatus, as an adjunct to post-operative care, is illustrated and discussed. These are but a few of the valuable additions to the book.

A study of the chapter on "The Surgical Intern" will well repay a new resident on a surgical service. He will find there details of daily usefulness.

A few minor criticisms present themselves: The treatment of warts by bismuth injections has not been as uniformly successful as indicated in the new references. The treatment of *Trichomonas vaginalis* infections merits more than the passing reference given it. No mention is made of the newer intravenous anesthetics especially useful in minor surgery. A discussion of suture materials might well be added.

This carefully revised third edition of this book will prove of great value to the general practitioner, consulting surgeon, and surgical house officers.

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Original Communications

THE RELATION OF THE SPREAD OF INFECTION TO FASCIAL PLANES IN THE NECK AND THORAX

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IN A previous communication,¹ we have discussed the relation of the spread of infection of the lip and face to the fascial planes of those parts. In the face we described three muscular fascial spaces:—the space for the body of the mandible, the masticator space, and the parotid space, and one viscerovascular space, the pterygopharyngomaxillary or the lateral pharyngeal space. We purpose here to describe the fascial spaces of the neck and thorax with special reference to the spread of infections in these regions. Due to the fact that many conflicting terms are applied to fasciae, we will, for the sake of clarity, repeat our previously expressed concept of types of fascial planes. Classified by their relation to the spread of infection, they are divided into two kinds, those associated with muscles and those surrounding viscera and vessels. The muscular fascial planes are always ultimately inserted into bone, thereby sharply limiting infections in these spaces. The viscerovascular fascial spaces extend along vessels and viscera in continuity with these structures, thereby allowing infection in them to pass readily from one region to another.

In the neck there are certain definite fascial planes of both sorts. After the skin, subcutaneous tissue, and platysma muscle have been reflected, we find the first muscular fascial plane of the neck enclosing the sternocleidomastoid and trapezius muscles. This fascia, shown in Fig. 1, is continuous above with the muscular fascial boundaries of the masticator space and extends downward to blend with the periosteum of the clavicle and sternum, corresponding with the muscular fascial plane of the pectoralis major muscle below the clavicle. Internal to this plane is found the second muscular fascial plane (shown in Fig. 2) in which lie the sternohyoid and omohyoid muscles. Above, it joins

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the first layer of fascia at the hyoid base to form the fused fascia, and below, at the superior surface of the sternum, it splits in two layers to form the suprasternal space, blending below with the periosteum of the anterior and posterior aspects of this bone. Lateral to this point the inferior border of the plane blends with the periosteum of the posterior border of the clavicle and with the upper border of the scapula where the omohyoid muscle is inserted. The lateral boundary of this plane continues around the neck between the trapezius and the deep



Fig. 1.—Dissection demonstrating the first muscular fascial plane. (A) Sternocleidomastoid with the first muscular fascial plane of the neck. (B) Pectoralis major at the same plane.

muscles of the neck to insert into the ligamentum nuchae. In its lower portion below the point of perforation by the external jugular vein, it ends in the fascia surrounding this vein. The suprasternal space shown in Fig. 3 contains lymph nodes, lymphatics, and the vein, making an anastomosis between the anterior jugular veins. This space may be infected indirectly by infection carried through the lymphatics or directly from osteomyelitis of the sternum. Between the first and second planes above described is a definite space of importance to the surgeon in his dissection, but of no important clinical significance, as it is rarely

if ever the site of infection. The third muscular fascial layer is composed of the fascia enclosing the sternothyroid and the thyrohyoid muscles continuing above to the hyoid bone. The lateral boundary of this layer fuses with the fascial sheath of the internal jugular vein, while inferiorly it is attached to the posterior border of the manubrium and the first rib. Between the second and third fascial planes is a space that is seldom infected. It has some importance to the surgeon, however, in



FIG. 2.—Dissection of the first muscular fascial plane (A), second muscular fascial plane (B), and fused fascia (C).

that by following this space laterally he will meet the internal jugular vein. These planes are shown in sagittal and cross-section in Figs. 3 and 4.

THE VISCEROVASCULAR SYSTEM

Thus far we have described layers of fascia that have originated from some part of the face and neck and have been inserted into some aspect of the upper portion of the bony wall of the thorax. We now

come to the highly important fascial compartment that extends from the skull to the fibrous portion of the pericardium in a cylindrical shape, enclosing the posterior and lateral walls of the pharynx, the ascending aorta, arch of the aorta, the subclavian and carotid artery and its branches, the internal jugular vein, the vagus and cervical sympathetics, the hypoglossal and spinal accessory nerves, and the submaxillary, thyroid, and thymus glands, the larynx, trachea, and esophagus.

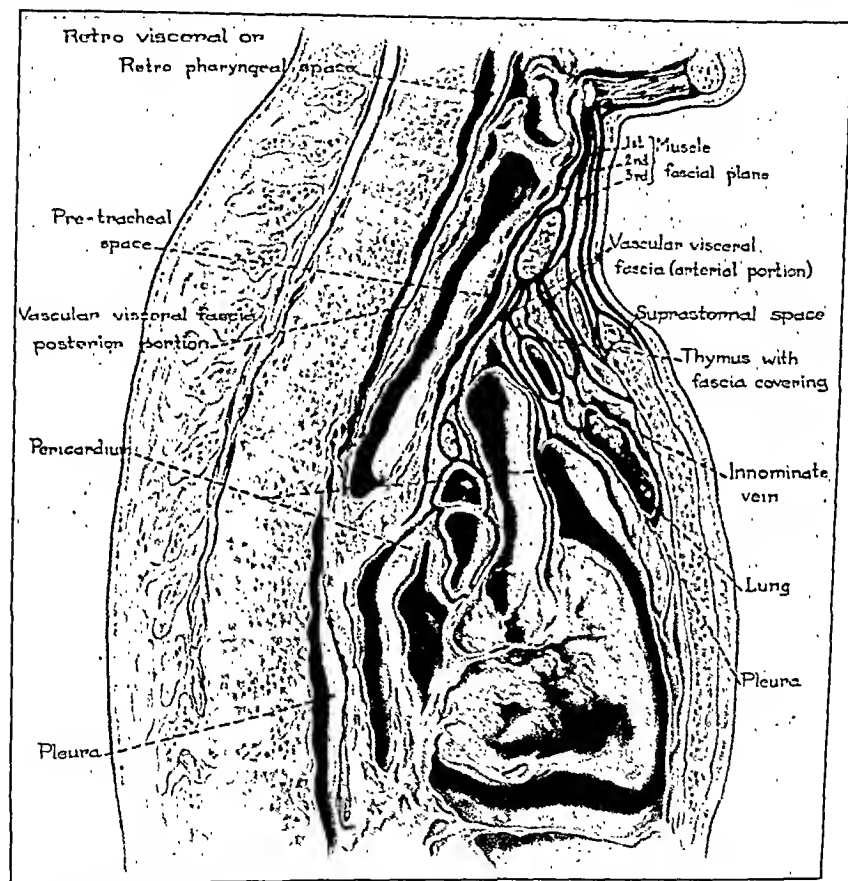


Fig. 3.—Sagittal section through neck and thorax showing fascial planes and spaces. (Drawing from dissection by the authors.)

This large space enclosed by the viscerovascular fascia is of the greatest importance to the surgeon since it connects the mouth, throat, and pharynx with the mediastinum through the neck and is the route along which infections commonly pass. For its clear understanding, on anatomic grounds and also because of the different clinical problems involved, we will discuss the various subdivisions of this huge space.

The portion of this system of fascia that lies posterior to the pharynx has been called the buccopharyngeal fascia, that layer lying anterior

to the trachea called the pretracheal fascia, and that portion surrounding the aorta and its branches called the vascular sheath. All of these fascial planes have usually been described as separate entities, but as shown in our dissection, they form subdivisions of this one large system of viscerovascular fascia.

The lateral pharyngeal space, previously described,¹ located between the lateral wall of the pharynx and the medial wall of the masticator and parotid spaces, lies closely related on its posterior wall with the internal carotid artery and the internal jugular vein. This space may be infected from the pharynx, and from the three important fascial spaces of the face, thereby acting as a portal of entry from all of these spaces to the large viscerovascular space or one of its subdivisions.

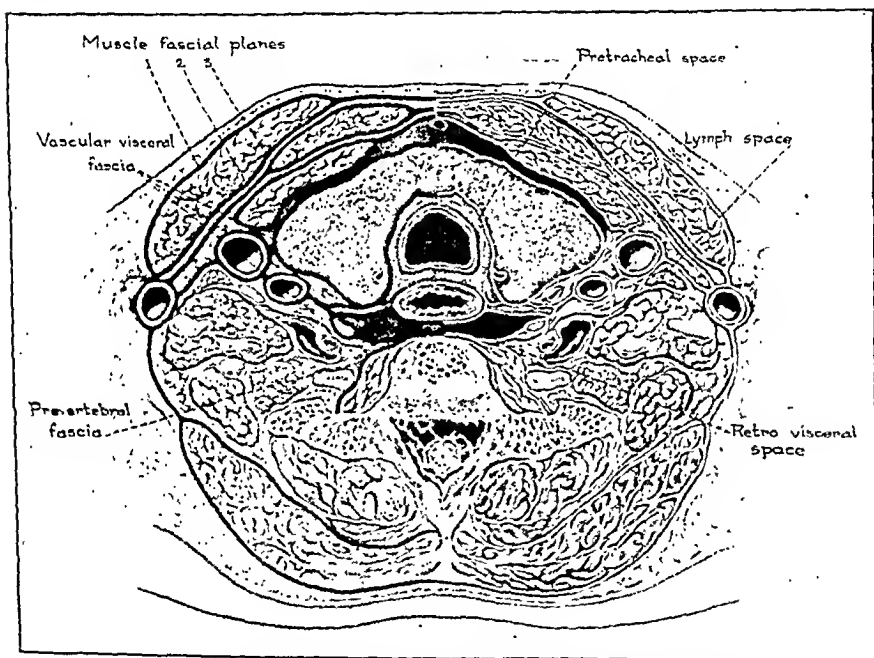


FIG. 1.—Horizontal section at the neck showing dissection of the fascial planes and spaces. (Drawing from dissection by the authors.)

SPACE OF THE SUBMAXILLARY GLAND

The submaxillary gland is enclosed by that portion of the viscerovascular fascia that surrounds the pharynx and covers the floor of the mouth. This gland with its fascial covering is separated from the parotid space and subcutaneous tissue by that part of the first and second muscular fascial planes of the neck called the fused fascia. The anterior belly of the digastric muscle and intermediary tendon and the insertion of the second muscular fascial plane to the hyoid bone act as a limiting wall below, to infection arising in the gland. These relations are well shown in Figs. 5 and 6. Posteriorly the fascial cover-

ing of the gland is connected to the external carotid sheath and forms the floor of the lateral pharyngeal space. In both situations, neglected infections may perforate and thus infect the viscerovascular space. There are in the submaxillary space, lymph nodes that communicate with the lymphatics of the mandible and the floor of the mouth. The space may therefore be infected either through the submaxillary duct from the mouth, often associated with the presence of calculi, this being a true infection of the submaxillary gland; or it may be infected sec-



Fig. 5.—Dissection showing the submaxillary gland with the fascial covering (A); (B), fused fascia; (C, D, E), first, second, and third fascial planes.

ondarily from infection of the lymph nodes contained in it. Infection here manifests itself commonly as a swelling below and anterior to the angle of the jaw and should be differentiated from Ludwig's angina, which is an infection of the intermuscular and sublingual spaces in the floor of the mouth with its chief swelling adjacent the midline. Both the submaxillary and sublingual spaces may be infected simultaneously through the lymphatics or by anatomic continuity along the duct as it passes between the myelohyoid and the hyoglossus muscles.

Infection in the space of the submaxillary gland can be drained through an incision made parallel to the lower border of the body of the mandible and about 1.5 cm. below it. The incision is carried directly through the skin and platysma and the fused fascia to the gland. Excision of the gland often offers the best drainage and is the procedure of choice if the gland is even partially destroyed by the infection. Drainage of the lateral pharyngeal space may likewise be carried out through the same skin incision. Mosher² has advocated drainage of the lateral pharyngeal space by turning the submaxillary gland upward, but as seen in Fig. 6, the lateral pharyngeal space can be reached more simply by carrying the dissection upward and posterior to the gland,

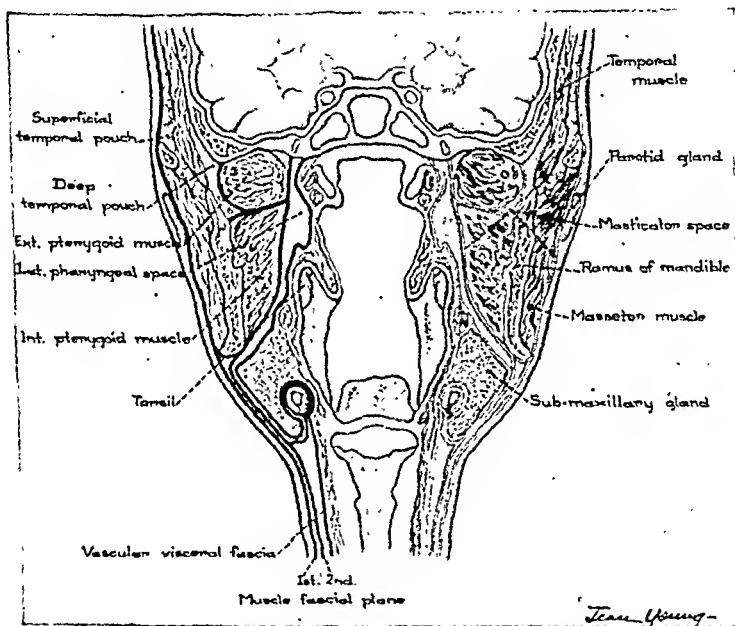


FIG. 6.—Frontal section demonstrating the different fascial planes and potential anatomic spaces. (Drawings from dissection by authors.) (This figure is taken from the article "Infections of the Lip and Face," *Surg., Gynec. & Obst.* 60: 277-290, 1935.)

passing between the gland and the internal pterygoid muscles. As mentioned in a previous article,¹ the lateral pharyngeal space may also be easily reached by a dissection passing posterior to the deep portion of the parotid and anterior to the external carotid artery.

PRETRACHEAL SPACE

The fascia from the submaxillary region is continued downward, to surround the larynx below which it encloses the thyroid gland and its arteries. The superficial leaf covering the anterior surface of the thyroid gland is separated from the third muscular fascial plane by loose areolar tissue, a line of cleavage utilized by surgeons in exposing

the thyroid gland. (See Figs. 3 and 4.) The deep leaf of this fascia on the posterior wall of the thyroid gland is intimately connected with the true carotid sheath laterally, and from here passes mesially and downward to surround the trachea and esophagus ending below in the fibrous pericardium, enclosing between its layers the aorta and its branches, thus forming this previsceral portion of the viscerovascular system of fascia. Between this previsceral portion and the trachea and

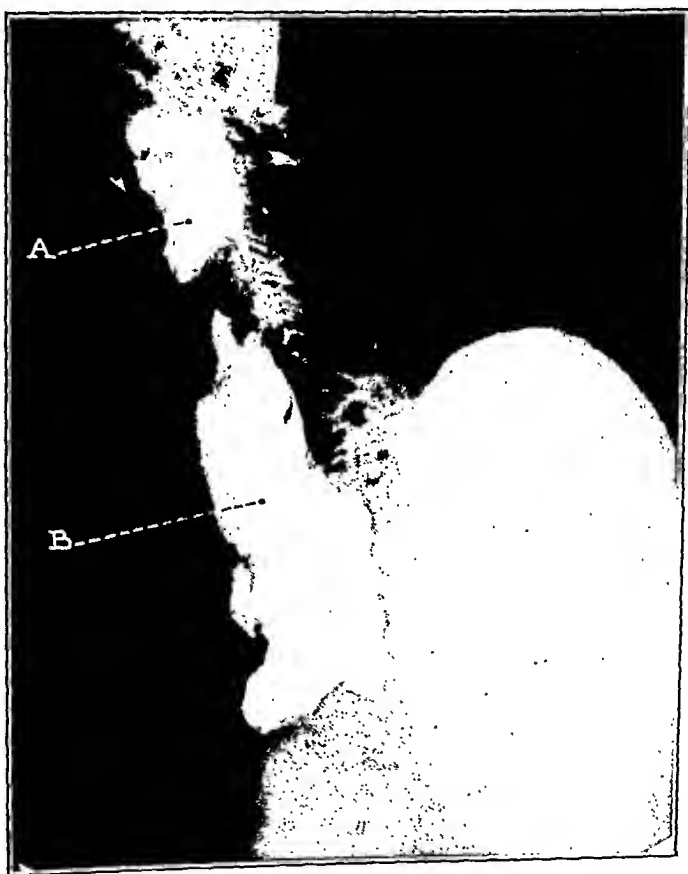


FIG. 7.—Lateral x-ray of injection of the pretracheal (B) and lateral pharyngeal space (A). Lateral pharyngeal injection is lying in front of the trachea and behind the sternum, and the close proximity of the injection of the lateral pharyngeal and pretracheal can be seen.

esophagus, lying posterior to it is a potential space known as the previsceral or pretracheal space. This space is partially obliterated at the level of the isthmus of the thyroid by a close areolar attachment of the isthmus to the larynx, and is continuous upward between the walls of the larynx and pharynx and the adjacent viscerovascular fascia. It extends below around the trachea to the point of fusion of these fasciae to the pericardium. Figs. 7 and 8 show roentgen rays of injection.

tion of the pretracheal space by an opaque substance below the level of the thyroid. The space is seen to be limited below by the pericardium and above by the superior attachments of the thyroid. Infections arising from the lateral wall of the pharynx such as a peritonsillar abscess or infection of the lateral pharyngeal space may extend down to infect this entire pretracheal space. Infections may also reach it from perforation of the anterior wall of the esophagus. This pathway for the spread of infection must be differentiated from that of the carotid and



Fig. 8.—Frontal x-ray of infection of the pretracheal space.

jugular sheath which lies lateral to it. That portion of the viscerovascular fascia surrounding the carotid artery and jugular vein forms the true sheath for these vessels and may be infected from the lateral pharyngeal space directly, but if this occurs, the infection remains limited to this sheath. Infection of the carotid sheath is not common, only accompanying thrombosis of the internal jugular vein. That division of the viscerovascular fascia thus described dealt with that portion of it enclosing the ascending aorta, the arch of the aorta, and the subclavian and carotid arteries, being eventually fixed to the fibrous

pericardium. Anterior to this and below the thyroid is another subdivision of the viscerovascular fascia of lesser surgical interest. Two compartments are formed as shown in Fig. 3. In the posterior lie the innominate veins and superior vena cava, and in the second just anterior is the thymus gland. Both of these fascial planes terminate below by fixation to the pleura. Between the fascia covering the great veins and that covering the arteries, as well as between the mediastinal pleura and the pericardium, lies a potential space, the pleuropericardial space. Infection of this space occurs in association with infections spreading down the sheath of the internal jugular vein and the carotid artery, but as a late manifestation of the process.

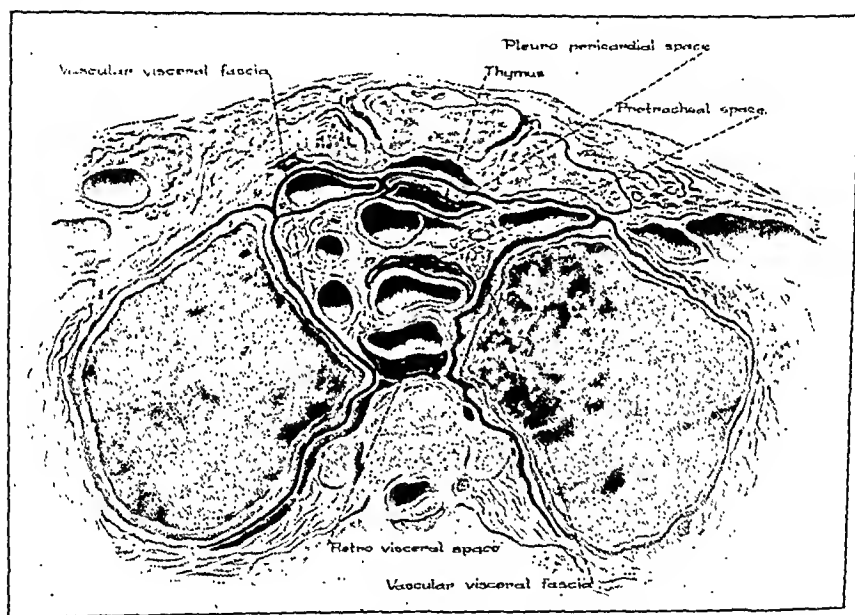


Fig. 9.—Horizontal section at the upper portion of the thorax showing the dissection of the fascial planes and spaces. (Drawing from dissection by the authors.)

RETROVISCERAL SPACE

The fascia that covers the posterior wall of the pharynx and esophagus is the retrovisceral portion of the viscerovascular system. Between this and the prevertebral fascia is a large and important space bounded laterally in the neck by the fusing of these fasciae at the point where they surround the cervical sympathetic chain. Above, it extends to the basilar process of the skull and is continuous below to the diaphragm. In the thorax, as shown in Figs. 3 and 9, the lateral boundaries are formed by the expansion of the sheath covering the descending aorta as it passes posterior to the parietal pleura to join the posterior wall of the thorax. Below the level of the bifurcation

of the trachea, the space becomes very small and may be entirely occluded at that level by the close approximation of the two pleurae. The space designated as the retrovisceral space is also known as the retropharyngeal or the prevertebral space. A lateral view of an opaque injection of this space is shown in Fig. 10.

Infections of the retropharyngeal space from the neck will descend with ease to this point, that is, at the bifurcation of the trachea, but

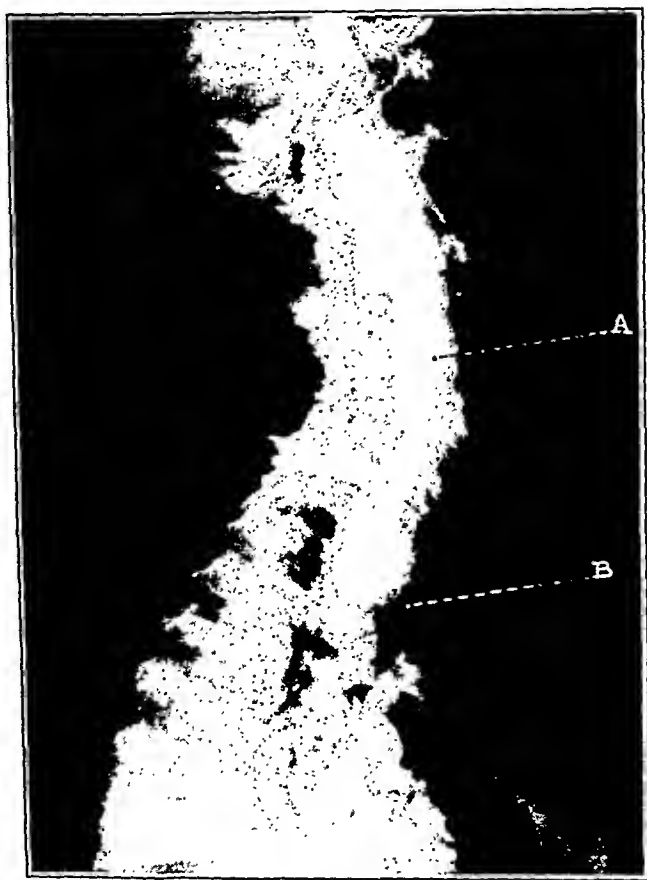


Fig. 10.—Lateral x-ray of infection of the retropharyngeal space (A) located posterior to the trachea (B).

may be stopped here by the obliteration of the space by the approximation of the pleurae at this point. Infections of the retropharyngeal space below this level are always secondary to lesions of the vertebrae and the ribs and by perforation of the esophagus below this level.

As shown in Fig. 3, any perforation of the esophagus in the posterior half of its wall may cause an infection of the retropharyngeal space. The retropharyngeal group of lymphatic nodes in this space may be infected secondary to primary infection arising in the ear, nose, throat,

or sinuses. Infection, either pyogenic or tuberculous, arising from any bone adjacent to this space, including the basilar process of the skull, the petrous portion of the temporal bone, the cervical and dorsal vertebrae, and the posterior ends of the ribs, may spread to the space. Infections in any of the cervical and the upper dorsal vertebrae will first produce a prevertebral abscess that is limited by the prevertebral fascia, muscles, and ligaments, and will remain localized there for varying lengths of time. Eventually perforation of the prevertebral fascia will take place, thus infecting secondarily the retrovisceral space. Infections in the lower dorsal and the first and second lumbar vertebrae will first be limited by the ligaments and the prevertebral fascia, but ultimately will perforate and spread to the lower portion of the retrovisceral space and tend to expand laterally between the pleurae and the expansion of the aortic sheath as it attaches to the thoracic wall. If infection originates in the posterior end of the ribs, the spread of the infection will be in a reverse direction from the ribs along the space between the pleura and the lateral expansion of the sheath of the descending aorta to the retrovisceral space. For these reasons, infections in the retrovisceral space above the fourth dorsal vertebra may best be drained by an incision in its upper portion in the neck, and infections below this point must be drained directly by posterior rib resection. Clinically this abscess will give rise to a variety of well-known signs and symptoms, depending upon its point of origin. After pus has entered the space, there will be dysphagia, dyspnea, and dysphonia, and examination will show a bulging of the posterior pharyngeal wall. In infants and young children, the chief symptom will be dyspnea, since the posterior wall of the trachea is less fixed and more compressible than is the trachea of an adult. In adults, the trachea is less easily compressed, and the chief symptom will be dysphagia due to compression of the esophagus. Roentgen ray examination will show an increase in the width of the retropharyngeal space in both the frontal and lateral projections.

Drainage of infection in the space may be carried out through an incision made along the anterior border of the sternocleidomastoid muscle at any desired level between the hyoid bone and the sternum, depending upon the level of the infection. After division of the skin, subcutaneous tissues, and platysma muscle, the first muscular fascial plane is divided along the anterior border of the sternocleidomastoid muscle, and this muscle is retracted laterally; the second muscular fascial plane is divided along the lateral border of the omohyoid muscle, and the third muscular fascial plane is incised and separated from the sheath of the internal jugular vein. The lateral or lower border of the thyroid gland is lifted and at the lower border of the thyroid is encountered the fascia passing from the lower border of the thyroid gland to the venous portion of the viscerovascular fascia and to the thymus gland.

After incising this fascia, we enter the upper portion of the pleuro-pericardial space, accomplishing now its drainage. Passing deeper, the pretracheal fascia may be incised, thus opening the pretracheal space. This same incision can be used for drainage of the retropharyngeal and vascular sheath in the following way if one desires: After passing through the third muscular fascial plane, the vascular sheath may be opened and thus drained. By following anterior to this sheath, the visceral portion of the viscerovascular fascia is divided along the lateral border of the esophagus, thus entering into the retropharyngeal space. Furstenberg³ has advocated drainage by this method on the right side, since the esophagus lies to the left of the median line, because of the greater number of lymph nodes on the right, and because of the farther



Fig. 11.—X-ray and photograph of a case of an abscess of the retrovisceral space at the superior portion of the thorax in which cervical drainage was done. (Courtesy of Dr. John Alexander.)

divergence of the right pleura from the median line, and the larger size of the space on the right. The retropharyngeal space may perhaps better be drained through an incision made posterior to the sternocleidomastoid muscle, by carrying the dissection through the first and second muscular planes, entering into the lymphatic space of the neck posterior to the jugular vein and carotid artery. The fascial expansion that includes the cervical sympathetic chain can be divided, and the retropharyngeal space entered and drained. This incision has a distinct advantage for drainage of this space alone, in that no other spaces of the neck are opened, and all drains are posterior to and not directly against the large vessels of the neck. An objection often advanced against this incision is that the sympathetic nerve may be injured, but we feel that there is very little chance of this, if the dissection is prop-

erly carried out, the dissection being effected in a vertical direction parallel to the direction of the nerve. Naturally early infection of this space originating from its upper portion and presenting in the posterior wall of the pharynx will first be drained by the time-honored method of direct incision at the site of the presenting tumor of the pharynx. If, however, the infection has passed to or originated in the lower portion of this space below the fourth cervical vertebra, drainage will probably be necessarily carried out by external thoracotomy. The site of election is determined by study of the lesion by x-ray, and a segment of a rib (or ribs) at the appropriate level on the prominent side is resected through a hockey-stick shaped skin incision. The internal periosteum is divided, and the wall of the abscess encountered and opened. The incision must be carried out as far mesially as possible.

The final space in the neck, of importance to the surgeon from its relation to infection, is that associated with the lymphatic chains. There are in general two groups of these lymph nodes shown in Fig. 4, one superficial, lying under the platysma muscle along the external jugular vein. These glands are often infected, but only produce localized subcutaneous abscesses and do not communicate with other fascial spaces in the neck. The second or deep group, however, lie in a space along the great vessels; the upper groups of these have already been mentioned in our previous article.¹ These lymph nodes lie in a triangular space bounded anteriorly by the sheath of the internal jugular vein and the common carotid artery; posteriorly, by the fascia covering the scalenus anticus muscle, the base of the triangle, being external, formed by the fascia connecting the internal and external jugular veins. The space extends upward to the mastoid and continues downward to the supraclavicular fossa. Here the lymphatic nodes end in the angle between the subclavian and internal jugular veins. The base of the supraclavicular fossa forms the apex of the axilla, being penetrated by the subclavian vessels. Infection extending down along this chain of nodes may pass directly to the axilla. The lymph nodes may be involved by an infection originating in the face, lips, mouth, tonsils, pharynx, or esophagus. When drainage becomes necessary, these lymphatics may be reached by the first stage of an incision previously described, made along the posterior border of the sternocleidomastoid muscle.

To summarize, we have described three spaces in the neck, lying between muscular fascial planes, that are limited by bony attachments above in the face, and below to the thoracic cage. Infections in these are infrequent and are limited sharply to the neck. Between these spaces and the prevertebral muscular fascia lies a large viscerovascular system of fascia in which we have described the presence of four definite fascial compartments and a vascular sheath. The lateral pharyngeal space is a receiving station for infections arising from fascial spaces

in the faec and pharynx, from which infection in turn may pass to all other compartments of the viscerovascular system. Two other compartments, the pretracheal and the retrovisceral, pass directly into the thorax. Infections passing along the sheath of the vessels will likewise pass directly to the thorax.

The mediastinum may be very simply divided into compartments if the above facts are borne in mind. Immediately behind the sternum is the space commonly called the anterior mediastinum, that is, a retrosternal space occupied by a few lymphatics, fat, and areolar tissue. It is bounded posteriorly by the pleurae and the fascia connecting them. It is of no surgical importance except in association with trauma and infection arising in the sternum. Posterior to this in its upper portion lie the thymus and innominate veins with their fascial covering walling off the upper part of the retrosternal space from the neck. Behind this, we come to the space lying between the pleura and pericardium, the pleuropericardial space, that may be infected from the vascular sheath or from the pretracheal space. Posterior to this space are the ascending aorta and the arch of the aorta with their sheaths. Behind them lie the pretracheal space and just behind this the retrovisceral space, both of supreme importance because they are the major pathways for the entrance of infection to the thorax.

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flammatory reaction to involve the colon to a point of actual penetration. In 1933, Benedict² in our clinic collected thirty-six gastrojejunal ulcers. Twenty-one of these were proved at operation and represented an incidence of 2.9 per cent. Adding fifteen x-ray and clinically diagnosed cases, the incidence is nearly 5 per cent in gastroenterostomies for duodenal ulcer in our hospital. No case of gastrojejunal ulcer followed gastroenterostomy for gastric ulcer during this period of



Fig. 1.—Schematic drawing representing condition found at operation. The vessels along the greater curvature of the stomach have been divided, and the gastrocolic omentum separated so that the lesion could be developed.

time. Five of these gastrojejunal ulcers were complicated by gastrojejunocolic fistulas, an incidence in this series of 23.8 per cent of the cases proved at operation, or 13.9 per cent of the entire group. Since this publication, we have treated five additional cases of gastrojejunocolic fistula following gastroenterostomy for duodenal ulcer, making a total of ten cases to date.

AN ASEPTIC TECHNIC APPLICABLE TO GASTROJEJUNOCOLIC FISTULA

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THE importance of avoiding gross contamination in surgery of the bowel has been evident since such operations were undertaken, peritonitis having been the most common cause of failure. To be sure, the peritoneum will withstand a great deal of infection, more in fact than most of the body tissues. Thus, gross soiling by intestinal contents at the time of operation will often fail to produce a fatal peritonitis. A constant or recurring insult such as that afforded by a leaking suture line will, on the other hand, almost invariably result fatally.

In the effort to avoid frank contamination, there have been many ingenious methods of so-called aseptic anastomoses devised. This has resulted in a greatly reduced mortality in intestinal surgery and has actually taken away so much of the hazard that these operations are undertaken with increasingly greater confidence as to the outcome. The evidence is such that one can offer no plausible excuse for any surgeon who fails to make use of one of these procedures. Perhaps he may prefer some modification which appeals to him as more logical or which suits his particular style of surgical technic. The fact remains, however, that complete disregard of some comparatively aseptic method of handling bowel suture, whether this be on the basis of more accurate approximation, fear of adequate blood supply, or any other argument, is absolutely unjustified. We have found Kerr's¹ technic, slightly modified, eminently successful after an extensive trial over a period of more than ten years.

Gastrojejunal fistula is fortunately a comparatively rare situation. It does occur, however, with sufficient frequency to offer one of the most trying problems with which the surgeon is forced to deal. Spontaneous fistulas may occur between the stomach and bowel or between the high small intestine and large bowel. These are usually based on carcinoma of the stomach with adherence and secondary involvement of the transverse colon with occasional erosion between these two structures. The reverse of this sequence is also possible. The majority of such fistulas, however, come about following the development of a marginal ulcer at the stoma of a previously made surgical anastomosis between the jejunum and the stomach. These marginal, stomal, or gastrojejunal ulcers do not all produce sufficient in-

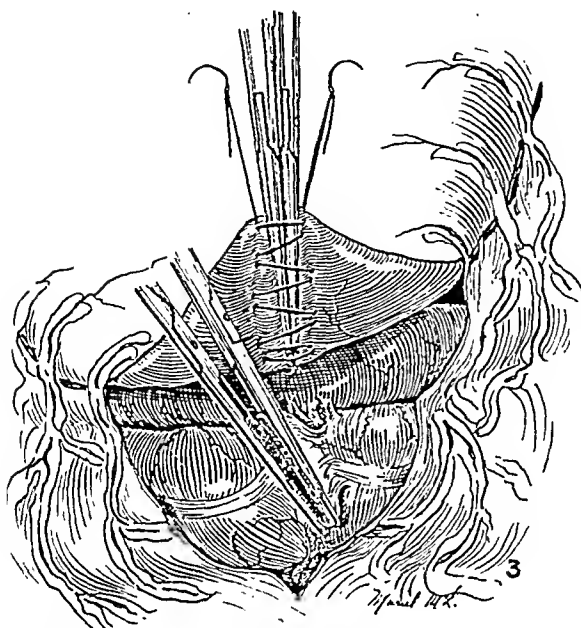


Fig. 3.—The stomach defect is being closed by continuous catgut sutures, one on the anterior surface and one on the posterior surface of the stomach. While these are drawn taut, the clamps are slipped out. A second row of sutures reinforces the opening in the stomach wall.

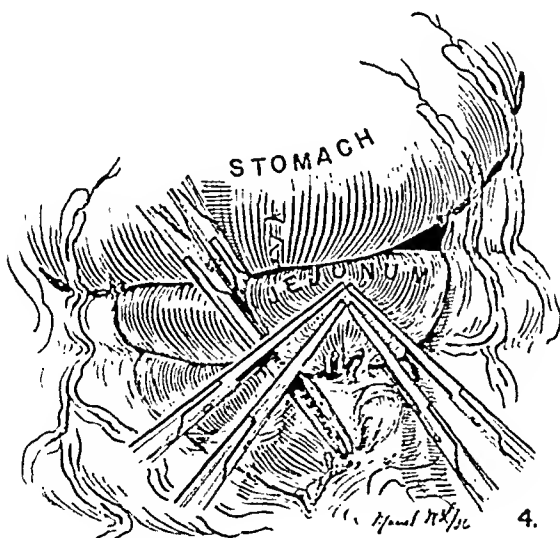


Fig. 4.—Note the hypertrophy of the jejunum usually found in such cases. In this instance, it was possible to remove a wedge-shaped piece of the jejunum between clamps with the actual cautery instead of a complete transverse section as is necessary in some instances. The defect in the jejunum was closed in the same manner as described in Fig. 3.

During this same period of time, four gastrocolic fistulas spontaneously developing as a complication to carcinoma of the stomach or transverse colon have been observed. These will not be considered further in this report.

Eight of the ten gastrojejunoecolic fistulas, subsequent to operations for duodenal ulcer, were subjected to radical operation. Two of these died of general peritonitis following a resection of the fistula and restoration of normal continuity. Six survived the operation. Four had resection of the stomach with Polya anastomosis at the same time.

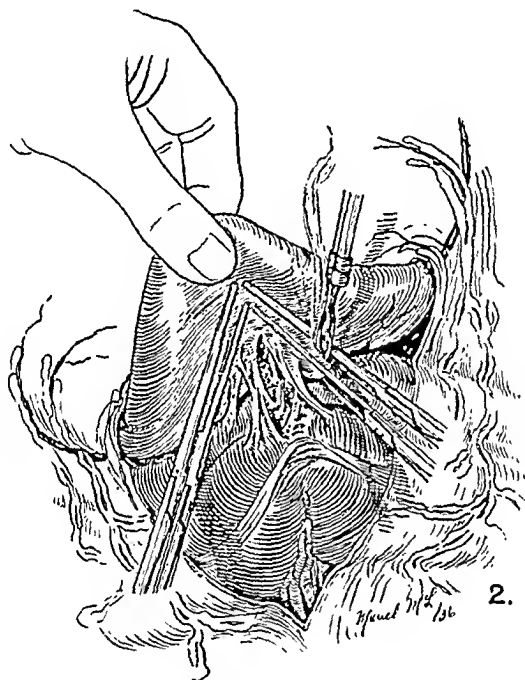


Fig. 2.—After freeing the greater curvature of the stomach and minor adhesions about the fistula, four long thin Kocher clamps have been applied about the stomach side of the stoma. This wedge-shaped section is freed by the actual cautery.

One had resection for recurrent duodenal ulcer with massive hemorrhage thirteen months following excision of his gastrojejunoecolic fistula and restoration of normal continuity. One is now symptom-free on a six meal bland diet four months after operation. (Case reported below, in detail.) It seems to be the rule for these patients to reactivate their duodenal ulcers if normal continuity is restored, so that this last patient will probably need partial gastrectomy at a later date, bearing in mind the likelihood that a logical physiologic control of all peptic ulcers will be discovered prior to the necessity of this crude and not perfectly satisfactory method of dealing with such

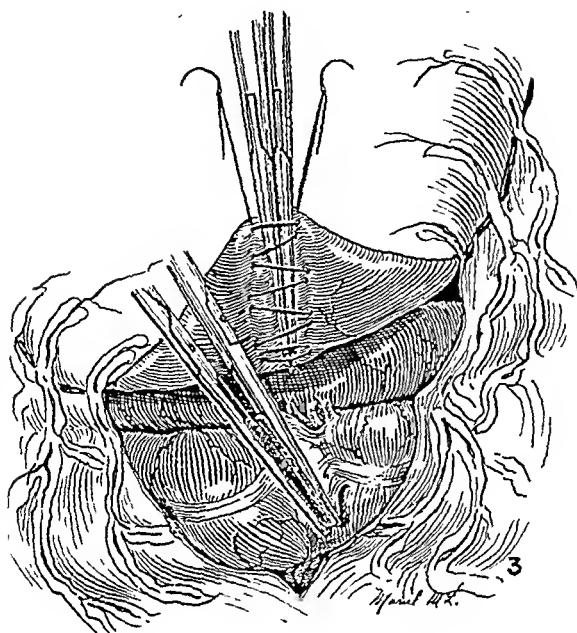


Fig. 3.—The stomach defect is being closed by continuous catgut sutures, one on the anterior surface and one on the posterior surface of the stomach. While these are drawn taut, the clamps are slipped out. A second row of sutures reenforces the opening in the stomach wall.

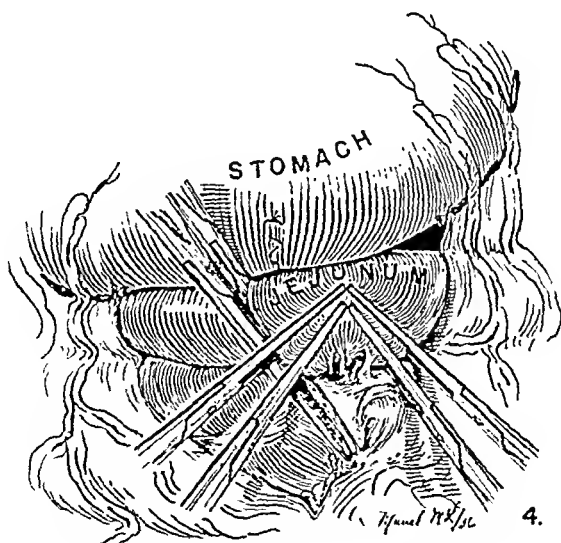


Fig. 4.—Note the hypertrophy of the jejunum usually found in such cases. In this instance, it was possible to remove a wedge-shaped piece of the jejunum between clamps with the actual cautery instead of a complete transverse section as is necessary in some instances. The defect in the jejunum was closed in the same manner as described in Fig. 3.

During this same period of time, four gastrocolic fistulas spontaneously developing as a complication to carcinoma of the stomach or transverse colon have been observed. These will not be considered further in this report.

Eight of the ten gastrojejunocolic fistulas, subsequent to operations for duodenal ulcer, were subjected to radical operation. Two of these died of general peritonitis following a resection of the fistula and restoration of normal continuity. Six survived the operation. Four had resection of the stomach with Polya anastomosis at the same time.

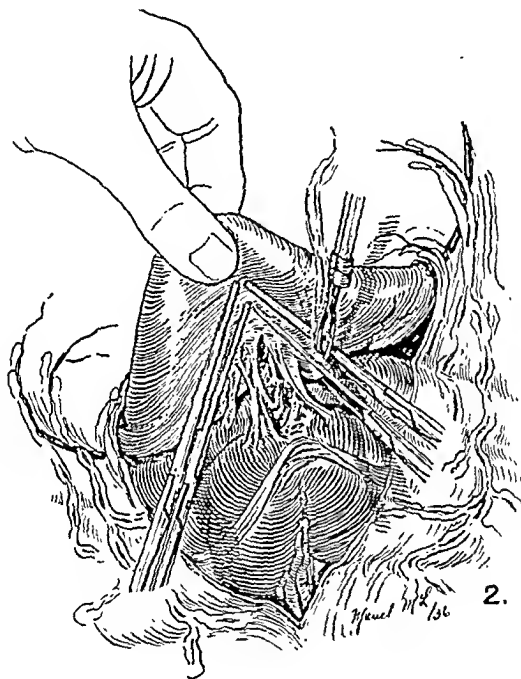


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lesions. No radical attempt was made to relieve the remaining two. One was in a severe state of malnutrition, with deficiency disease in its most advanced form already present on entering the hospital. He refused treatment, went home against advice, and died twenty-one days later. The remaining patient in this group was seventy-two years of age; he had had two previous operations on his stomach and improved somewhat on a careful dietary regime.

Every surgeon who has to deal with these lesions is grateful for any suggestions that make the operative procedure simpler and safer.

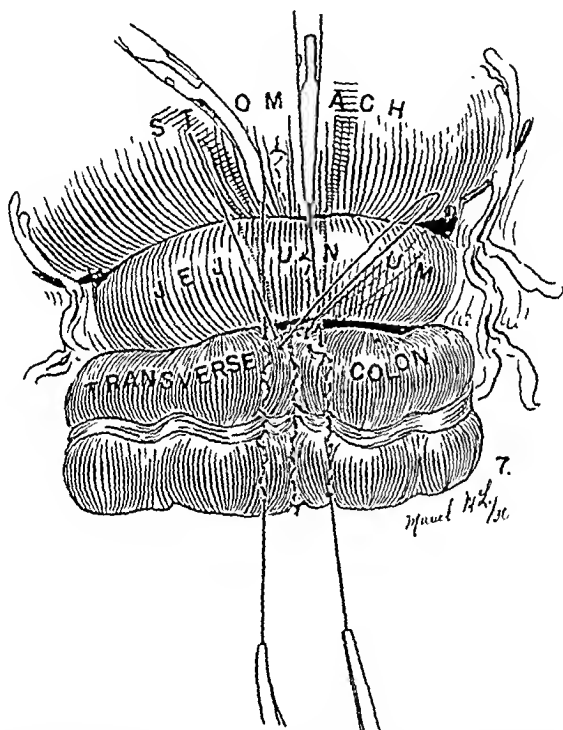


Fig. 7.—The clamps have been withdrawn and the basting stitches brought up tightly, temporarily closing in the cut ends of the bowel. A second posterior row of stitches is now applied.

Based on the experiments of Mann and Williamson³ demonstrating that chronic ulcers can be produced by exposing duodenal mucosa to the gastric secretions unmodified by the normal duodenal contents, and further that these experimental ulcers heal if the normal relationships are restored, Schrimger⁴ recently has called attention to some basic factors in dealing with gastrojejunal ulcers and gastrojejuno-colic fistulas. He has added his own observations that the gastrointestinal tract will heal by approximation of the muscularis if the mucosa is previously removed. Schrimger advocates leaving the

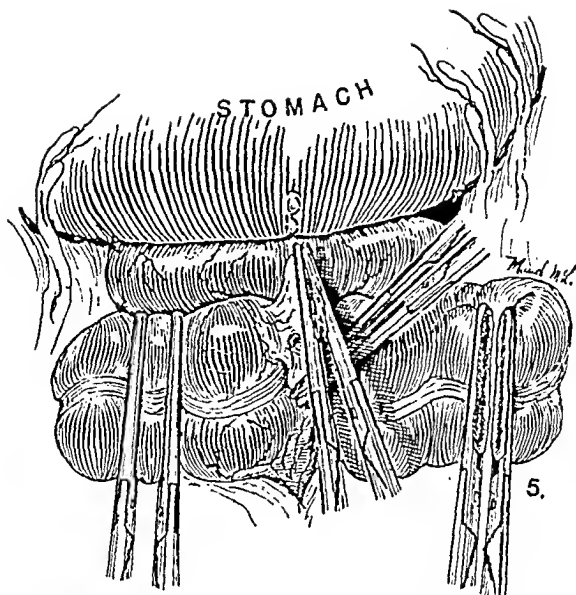


Fig. 5.—Section of the transverse colon now completely freed of blood supply, and its attachment to the jejunum and stomach is burned out between clamps.

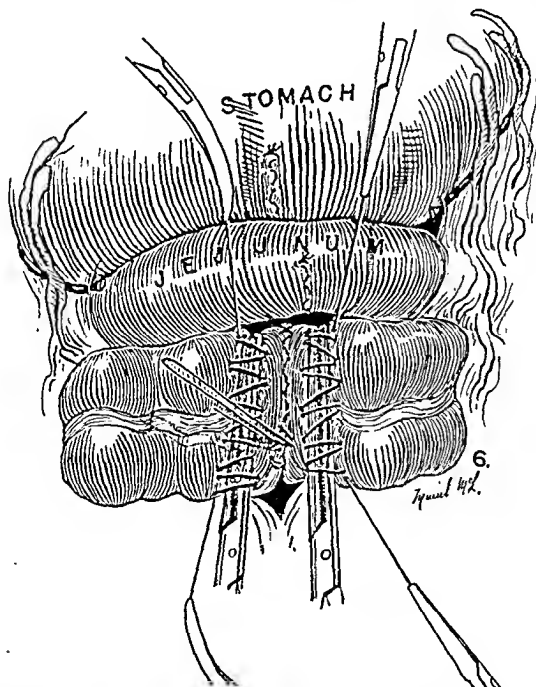


Fig. 6.—First and second steps in the modified Kerr anastomosis in the transverse colon. Note that the basting stitch later to be withdrawn is marked on one side with curved hemostats and on the other side with straight forceps for purposes of identification later. Also, note that the first posterior row of stitches is placed before the clamps are withdrawn. This keeps the bowel ends in approximation while the remaining layers of sutures are placed.

jejunal ulcerations even if the colon has been penetrated, resecting three-quarters of the stomach with the exception of a portion one and one-half inches wide around the old stoma. From this remaining area, the mucosa is removed, and the muscularis and peritoneal coat sutured by everting the edges as in arterial suture. This simplifies the closure of these thickened structures and has in five instances resulted in firm healing. There was an unfortunate late death in the one case of gastrojejunocolic fistula of the series from a leak in his anterior Polya anastomosis. The method resulted in excellent recovery in the four patients with uncomplicated jejunal ulcers. Estes⁵ in his discussion of Schrimmer's paper before the American Surgical Association in

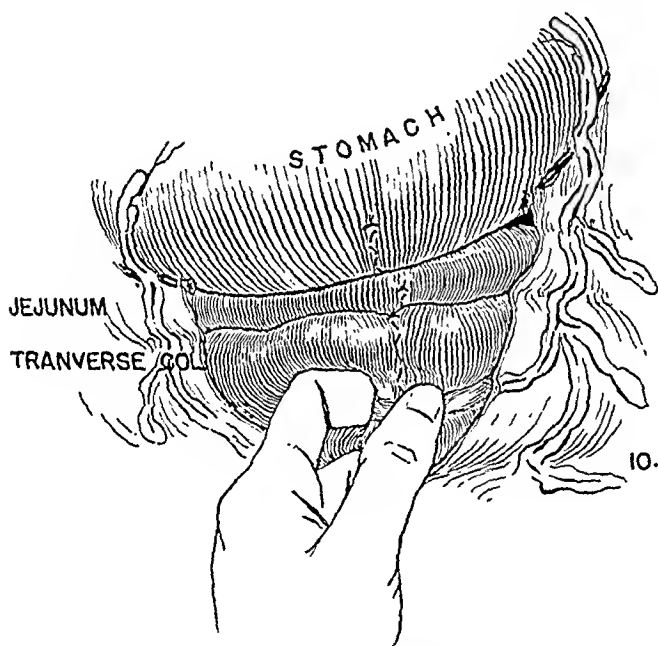


Fig. 10.—A most important step in the Kerr aseptic technic. The cautery-seared surfaces have a tendency to remain glued together after the basting stitch has been withdrawn. One must be absolutely certain that this seal is definitely broken by in-vagination over the thumb and finger. The operation is finished by a careful approximation of the gastrocolic omentum over the suture lines.

1935 called attention to a somewhat similar technic which he had reported before the Johns Hopkins Surgical Society four years before. He had inverted a cuff of stomach about a gastrojejunal ulcer and made a lateral anastomosis around the lesion in the jejunum. Much to his delight, when the patient was reoperated upon a few weeks later for a reactivated duodenal ulcer, he found the old jejunal ulceration completely healed, and the jejunum in this region atrophied.

Presented with the problem of a gastrojejunocolic fistula recently, it was decided to take into consideration the possibilities brought

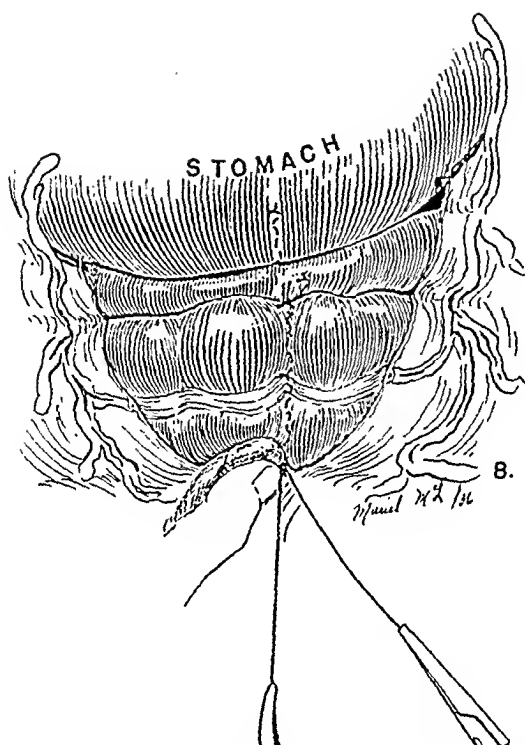


Fig. 8.—The first row of sutures anteriorly has been applied over the basting stitch. The basting stitches have been cut at the upper border and are ready to be withdrawn.

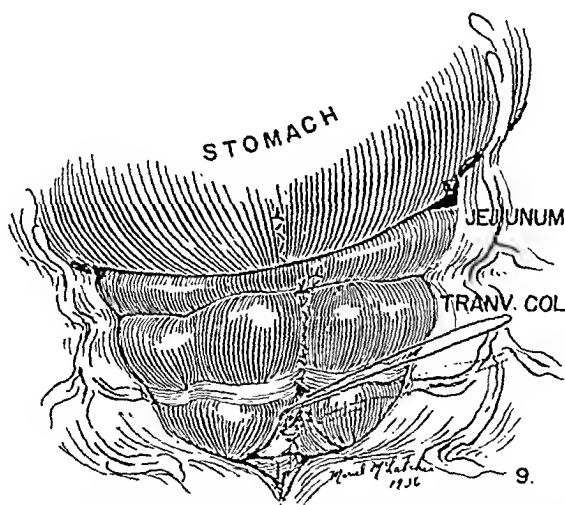


Fig. 9.—The second row of sutures is applied anteriorly. This method approximates a fairly wide serosal surface at the anastomosis. This, we believe, should be approximately 5 mm. in width.

the stomach by an aseptic Billroth II, although it is my opinion that Kerr's technic as applied to gastrojejunostomy is less adaptable than it is when used in the bowel alone. This fear is based primarily on the possibility of inadequate control of hemorrhage on the thick stomach wall.

CASE REPORT.—No. 350824: A thirty-year-old, married laborer entered the medical wards of the hospital on January 10, 1936, complaining of diarrhea, weight loss, and abnormal appetite for two years. He had been operated upon in another hospital six years before for a perforated duodenal ulcer. A posterior gastroenterostomy had been done at the time of the suture of the perforation. He had been well until two years ago, when he suddenly developed diarrhea eighteen times a day. He lost forty-three pounds in weight in spite of eating three times as much as a normal individual and drinking fifteen glasses of water daily. Aside from duodenal ulcer symptoms starting seven years ago, his past history is irrelevant. His family history is not contributory. Physical examination on entry showed an emaciated man, with a fecal odor to his breath, in no distress. The teeth were poor. Bubbling râles were heard throughout the chest; there was some cough from recent infection. A blowing systolic murmur was heard at the apex. The blood pressure was 107/60. The abdomen was distended and full and tympanic throughout. There was a sense of resistance under the epigastric scar. Very loud peristalsis could be heard. X-ray examination showed considerable gastritis and a posterior gastroenterostomy with small stoma, some of the barium passing directly into the transverse colon. This was confirmed by barium enema. Definite diagnosis of gastrojejunocolic fistula was made.

Laboratory studies revealed a serum protein of 4.5 per cent. Gastric analysis showed a normal amount of free and total acid. His leucocyte count was around 17,000 on four successive days; hemoglobin, 70 per cent; red cells, 4,500,000. The stools were filled with undigested food particles.

Patient improved somewhat while in the ward and gained some weight. Inasmuch as his upper respiratory tract infection was slow in clearing, he was discharged home on February 8, 1936, four weeks after entry, to return later for operation.

Second admission to the surgical wards on June 6, 1936. The patient had found that by remaining quiet at home he could maintain the gain which he had made in the hospital. Any activity, however, increased his diarrhea and caused weight loss. On this admission his serum protein was 3.6 per cent. He was given a blood transfusion and subjected to operation on June 12, 1936. The operative procedure carried out was an aseptic resection of the gastrojejunocolic fistula with closure of the three structures involved as depicted in Figs. 1-10. He has remained well for four months on a six-meal bland diet. He is able to work. He is being followed in the Gastrointestinal Clinic and will be readmitted if the original ulcer in the duodenum becomes reactivated.

SUMMARY AND CONCLUSIONS

1. The importance of approximate aseptic handling of structures infected with colon and intestinal contents is stressed.
2. A method applicable to one case of gastrojejunocolic fistula is related in detail.
3. The incidence of gastrojejunocolic fistula developing on post-operative gastrojejunal ulcer in our hospital is approximately 14 per cent.

forth in Schrimmer's paper and Estes' discussion, combining if possible, some modification that would eliminate contamination of the peritoneal cavity, since in dealing with this lesion we must face the fact that the stomach and jejunum will contain the same bacteria as the colon itself; this was brought forcibly to mind by the fact that two out of eight patients operated upon by the open method in our hospital had succumbed to peritonitis. Theorizing about the possibilities prior to the operation, we decided that in order to eliminate the septic factor, we were probably committed to a two-stage procedure. Could we use the ideas of Estes and Schrimmer and aseptically separate a wedge of stomach around the stoma between clamps with the cautery, close the cuff and the opening in the stomach, and leave the resection and Polya anastomosis for a future operation? Would it

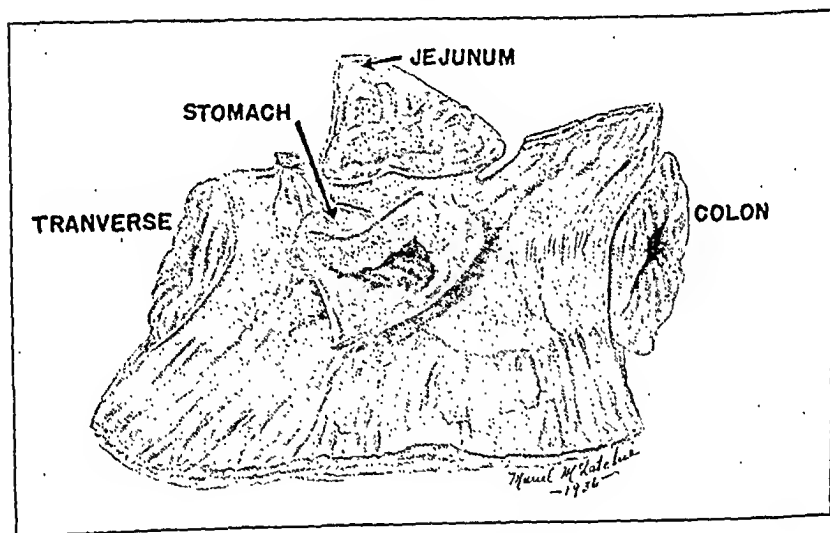


Fig. 11.—Photograph of a specimen of gastrojejuno-colic fistula removed by aseptic technic. (See Case Report.)

be feasible to transect the transverse colon on either side of the fistula, do an end-to-end union and leave behind the segment of colon to which the stoma was attached? This last possibility might be considered seriously when dealing with an extremely large ulceration into the colon. Wilkie⁶ used this idea in dealing with a gastrojejuno-colic fistula that had developed spontaneously in a posterior wall gastric ulcer. We might dare attempt both steps, leaving the stomach closed and the colon reanastomosed, depending on the opening from the colon into the jejunum to take care of the infection in the remaining segment of colon. If the endurance of the surgeon and the patient were adequate, one might carry on this idea of aseptic resection to include half or two-thirds of the stomach and join the remaining portion of

SPONTANEOUS INTERNAL BILIARY FISTULA AND GALLSTONE OBSTRUCTION

WITH PARTICULAR REFERENCE TO THE ROENTGENOLOGIC DIAGNOSIS*

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THE incidence of spontaneous internal biliary fistula in operative and autopsy records is very low, but it is probable that the actual frequency is greater than such statistics would indicate. Some idea of this reported incidence may be obtained in Table I. Although less than 10 cases, in which the diagnosis had been made by roentgen examination, were reported prior to 1928, since that time over 50 cases of true fistula, not including postoperative cases, have appeared in the roentgenologic literature. The ability to recognize, by means of x-ray examination alone, both a true internal fistulous connection be-

TABLE I
INCIDENCE OF SPONTANEOUS INTERNAL BILIARY FISTULA

AUTHORS	NO. CASES EXAMINED	POSITIVE FINDINGS	PER CENT
Roth, Schroeder and Schloth	10,866 (autopsies)	43	0.39
University of Minnesota Hospital	19,474 (autopsies)	24	0.12
Kehr	2,000 (cholecystectomies)	100	5.0

tween the biliary system and the gastrointestinal tract and a fistulous dilatation of the common bile duct has resulted in a rapid accumulation of recorded instances. As time goes on, this method of diagnosis will no doubt change our previous concept of the rarity of this condition.

The importance of the demonstration of a spontaneous internal biliary fistula, both with regard to the lesion itself and as a finding indicative of gallstone obstruction, cannot be exaggerated. The diagnosis of this condition can be accurately made by roentgen examination alone in such a high percentage of cases that some emphasis on the roentgen findings seems advisable.

PATHOLOGY

Anatomically, the path taken by a biliary fistula is by no means limited. Gallstones have been vomited from the stomach, coughed up from the bronchial tree, voided in the urine, and frequently passed

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4. The mortality in this small group of ten cases was 30 per cent.
5. The mortality for radical operation to relieve this situation in this series was 25 per cent.
6. Selected cases may be treated by conservative measures.

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associated cholecystitis and cholelithiasis. In 14 of 16 cases of the choledochoduodenal type reported in the roentgenologic literature, a diagnosis of duodenal ulcer was indicated either by the clinical history or by the operative findings. Neoplastic growths have been said to be associated with the cholecystocolic type of fistula more than in any of the other types. Mureheson,⁷⁷ for example, found carcinoma as the cause in 6 out of 9 cases. Most of the cases recognized on x-ray examination, however, have been due to gallstones. In our autopsy records only one of 6 cases was associated with a carcinoma.

Common duct obstruction, usually by a stone, with a patent cystic duct, is an important associated pathologic condition. The biliary obstruction thus produced is the initial factor in the fistula formation. Even though a stone is not found in the common duct at operation, evidence of previous obstruction is nearly always present. The intimate anatomic relationship between a distended gallbladder and the second part of the duodenum accounts, no doubt, for the greater frequency of fistulas between these two organs. Similarly the proximity of the common duct to the first portion of the duodenum, as it courses in the hepatoduodenal ligament, may account for the association of duodenal ulcer with fistulas into the common duct.

There is general agreement as to the usual pathologic process concerned in the formation of a fistula, and this has been sufficiently discussed in previous papers^{75, 102} so that it need not be repeated here. Attention, however, should be called to the fact that a regurgitation from the intestinal tract through the fistula into the biliary system may occur and, consequently, intestinal contents can be demonstrated in the bile ducts. Gas under definite pressure has been found in a number of cases in which the common duct has been explored at operation. This accounts, no doubt, for the roentgenologic findings which will be described later.

A fistulous tract once formed may close spontaneously upon removal of the obstructing factor. The only resulting evidence of the fistula, then remaining, is visceral adhesions between the organs involved. It is probably for this reason that biliary fistulas are so rarely found at the autopsy table. Courvoisier's²² statement that there are three times as many cases of intestinal obstruction due to gallstones, reported in the literature, as there are cases of gallbladder-intestinal fistula, emphasized the fact that internal biliary fistula must be a much more frequent occurrence than postmortem statistics would indicate. In all these cases of gallstone obstruction a fistulous opening must have been formed or the common duct dilated to a fistulous character, but the disappearance of the fistula prevents its detection, either at operation or at autopsy.

In the majority of instances gallstones probably enter the intestinal tract through the common duct rather than by true fistula formation.

per rectum. Fistulous tracts have been found between the gallbladder and the stomach, duodenum, jejunum, ileum, colon, and appendix; between the gallbladder, the common and hepatic ducts, and the liver. They have been traced to the pelvis of the kidney, the urachus, the urinary bladder, and the sex organs. Extreme rarities are connections with the pericardial cavity, the pregnant uterus, and an ovarian cyst. The most frequent tract is between the gallbladder and the first and second portions of the duodenum. In the majority of cholecystoduodenal fistulas the gallbladder is connected directly to the proximal part of the second portion of the duodenum. The occurrence of a fistula between the bile ducts and the duodenum (choledochoduodenal), according to the collected autopsy cases, forms only a small percentage of the group. Moynihan⁷⁶ has stated, however, that the choledochoduodenal type probably occurs with greater frequency than

TABLE II

CLASSIFICATION OF TYPES OF INTERNAL BILIARY FISTULA BASED ON AUTOPSY STATISTICS, AND COMPARISON WITH TYPES DIAGNOSED BY ROENTGEN EXAMINATION

	NAU- NYN ⁷⁸	PER CENT	ROTH, SCHIROE- DER AND SCHLOTH	PER CENT	UNIV. OF MINN. AU- TOPSIES	PER CENT	ROENT- GENOLOG- ICALLY DI- AGNOSED CASES*	PER CENT
Total number cases	200		43		24		83	
Cholecystoduodenal	93	46.5	19	44.0	17	70.0	31	37.0
Choledochoduodenal	15	7.5	5	11.0	1	4.0	16	19.2
Cholecystocolic	49	24.5	16	37.0	6	25.0	10	14.4
Cholecystogastric	8	4.0	1	2.3			3	3.6
Regurgitation through common duct							16	19.2

The discrepancy between the total number of cases reported by each author and the total of the classified cases under his name is due to inclusion of only five types of fistulas in the classification.

*Does not include herein reported cases.

has been thought. This is borne out by cases reported in the roentgen literature in which this type of fistula forms a much greater percentage of the total than the autopsy statistics would indicate. The classification of the previously reported groups of autopsy cases is shown in Table II, which includes also a classification of the types of cases found in our own autopsy series.

Internal biliary fistulas are most frequently caused by gallstones. Perforating duodenal ulcers constitute the second most important cause, while neoplastic growths are only an occasional etiologic factor. Only 23 of the 153 cases reported by Judd⁸¹ showed no evidence of stones. In 23 of the 24 cases found by us in the autopsy records of the Department of Pathology of the University of Minnesota, there was an

associated cholecystitis and cholelithiasis. In 14 of 16 cases of the choledochoduodenal type reported in the roentgenologic literature, a diagnosis of duodenal ulcer was indicated either by the clinical history or by the operative findings. Neoplastic growths have been said to be associated with the cholecystocolic type of fistula more than in any of the other types. Murcheson,⁷⁷ for example, found carcinoma as the cause in 6 out of 9 cases. Most of the cases recognized on x-ray examination, however, have been due to gallstones. In our autopsy records only one of 6 cases was associated with a carcinoma.

Common duct obstruction, usually by a stone, with a patent cystic duct, is an important associated pathologic condition. The biliary obstruction thus produced is the initial factor in the fistula formation. Even though a stone is not found in the common duct at operation, evidence of previous obstruction is nearly always present. The intimate anatomic relationship between a distended gallbladder and the second part of the duodenum accounts, no doubt, for the greater frequency of fistulas between these two organs. Similarly the proximity of the common duct to the first portion of the duodenum, as it courses in the hepatoduodenal ligament, may account for the association of duodenal ulcer with fistulas into the common duct.

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In the majority of instances gallstones probably enter the intestinal tract through the common duct rather than by true fistula formation.

The ability of the common duct to pass stones large enough to produce intestinal obstruction is amazing, but verified reports of such cases have been recorded. From the roentgenologic standpoint such a passage produces a condition which is quite similar to a true internal biliary fistula. Dilatation of the terminal portion of the common duct by a passing stone often results in a temporary or permanent loss of the sphincteric function formerly present in the distal end of the duct, and in the duodenal wall. Williams and Bush¹¹⁸ have cited anatomic and experimental evidence to prove that an incompetent sphincter of Oddi is most commonly caused by the passage through it of a large stone. Åkerlund,¹ however, has shown that chronic pancreatitis may also be related to an incompetent sphincter; temporary incompetence likewise occurs following cholecystectomy. As in the case of a true fistula, regurgitation can be brought about by increasing the duodenal pressure, below the sphincter of Oddi, above that of the biliary pressure in the common duct. Clinically also the condition may resemble, in certain respects, a true internal fistula. In consideration of the frequency of common duct stones and their passage into the intestinal tract, it is logical to suspect that a loss of this sphincteric action is frequently found. Courvoisier,²² in studying a series of cases of common duct stones, found that 14 per cent had a dilated and wide open ampulla of Vater. Since an incompetent sphincteric action is difficult to demonstrate at the postmortem table, it follows that this condition may be diagnosed by x-ray examination far more frequently than autopsy statistics would indicate. It will be noted in Table II that practically 20 per cent of the cases diagnosed by roentgen examination show this type of fistulous formation. For practical purposes, this mode of communication between the biliary tree and the intestines may be considered fistulous even though the tract is through a natural duct.

CLINICAL FINDINGS

Sudden and unusual relief from long-standing intermittent gall-bladder pain and jaundice constitute the chief clinical features of spontaneous internal biliary fistula. Nevertheless, cases have been reported with absence of any symptoms referable to this condition. Despite the reflux of gastrointestinal contents into the biliary system, clinical cholangitis is not a frequent finding. The absence of evidence of infection, however, does not preclude the possibility of pathologic changes occurring in the biliary tract and liver, as has been pointed out by Beaver.⁷ Diarrhea, cramps, and emaciation are frequently associated with the cholecystocolic type of fistula, while symptoms suggesting intestinal obstruction in varying degrees are present in about one-half of all types of cases. Some degree of chronic cholecystitis is practically always present in all cases, and an active fistula will usually perpetuate the symptoms which have been present. A

relative absence of symptoms, in the presence of an active fistula, is, no doubt, explained by the wide open stoma and the free drainage of the biliary system which this permits. A well-healed fistula may produce no definite symptoms whatever.

ROENTGENOLOGIC DIAGNOSIS

Previous to the era of roentgen diagnosis the preoperative or ante mortem diagnosis of internal biliary fistula was seldom if ever made. Emesis of a gallstone or its passage per rectum constituted practically the sole diagnostic sign. At the present time certain roentgenologic criteria indicate the presence of internal fistula with almost positive certainty, and these can be obtained with relative ease.

In 1915, Hunt and Herbst⁴⁷ reported a case in which the barium meal study showed an apparent duodenal diverticulum. At operation, subsequently, a cholecystoduodenal fistula was found. Case,²¹ in 1916, reported the x-ray findings in two cases of postoperative cholecysto-enterostomies. A year later Carman and Miller²⁰ observed filling of the biliary tree with barium and at operation a cholecystoduodenal fistula was present. In 1919, Busi¹⁷ observed both gas and barium in the bile ducts, assumed a fistulous connection with the intestinal tract to be the cause, and the diagnosis was substantiated at operation. Judd and Burden,⁵¹ in 1925, reported 153 cases of spontaneous internal biliary fistula, only one of which had been diagnosed by x-ray examination. In 24 cases found in the autopsy records of the Department of Pathology of the University of Minnesota from 1925 to 1935, only one case had been diagnosed by this means. Since 1928, however, numerous reports have appeared, there being at this time 78 recorded cases in the literature, if the cases of dilated common duct be included. To these we wish to add 8 cases of our own. The cases previously reported as diagnosed by roentgen examination are listed in Table III and the classification as to types is indicated. In this table are also included the cases artificially produced by surgical procedures which have been demonstrated by x-ray examination. The cases, roentgenologically diagnosed, which we are reporting, are summarized in Table IV.

The roentgenologic signs of internal biliary fistula may be summarized briefly as follows:

1. Direct Signs
 - a. Gas, or barium, or both in the gallbladder or biliary tree.
 - b. Mucous membrane changes at the stoma of the fistula.
2. Indirect Signs
 - a. Nonfunctioning gallbladder (cholecystogram).

The most important x-ray sign of an internal biliary fistula is the presence of gas in the gallbladder or bile ducts. It must be borne in mind, however, that this may occur as a result of three conditions.

The ability of the common duct to pass stones large enough to produce intestinal obstruction is amazing, but verified reports of such cases have been recorded. From the roentgenologic standpoint such a passage produces a condition which is quite similar to a true internal biliary fistula. Dilatation of the terminal portion of the common duct by a passing stone often results in a temporary or permanent loss of the sphincteric function formerly present in the distal end of the duct, and in the duodenal wall. Williams and Bush¹¹⁸ have cited anatomic and experimental evidence to prove that an incompetent sphincter of Oddi is most commonly caused by the passage through it of a large stone. Åkerlund,¹ however, has shown that chronic pancreatitis may also be related to an incompetent sphincter; temporary incompetence likewise occurs following cholecystectomy. As in the case of a true fistula, regurgitation can be brought about by increasing the duodenal pressure, below the sphincter of Oddi, above that of the biliary pressure in the common duct. Clinically also the condition may resemble, in certain respects, a true internal fistula. In consideration of the frequency of common duct stones and their passage into the intestinal tract, it is logical to suspect that a loss of this sphincteric action is frequently found. Courvoisier,²² in studying a series of cases of common duct stones, found that 14 per cent had a dilated and wide open ampulla of Vater. Since an incompetent sphincteric action is difficult to demonstrate at the postmortem table, it follows that this condition may be diagnosed by x-ray examination far more frequently than autopsy statistics would indicate. It will be noted in Table II that practically 20 per cent of the cases diagnosed by roentgen examination show this type of fistulous formation. For practical purposes, this mode of communication between the biliary tree and the intestines may be considered fistulous even though the tract is through a natural duct.

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1. Spontaneous or operative fistulous connection between some part of the biliary system and the gastrointestinal tract.
2. Regurgitation through the sphincter of Oddi via the ampulla of Vater.
3. Emphysema from bacterial action.

The presence of gas in the biliary ducts (Figs. 1, 4, and 7) may be detected by linear areas of rarefaction, tubular in shape, and with the characteristic branching of the bile ducts. In some respects gas may be detected more easily than barium, as it may be shown in the ordinary films of the gallbladder region without the use of any contrast media. While the vascular markings of the liver may rarely simulate a gas-filled biliary tree, the shape of the bile ducts is usually so characteristic that they are unmistakable. The visualization of the gas-containing biliary system gives less specific information than does the presence of barium as to the type of pathology present, in that no localization of the fistula may thus be obtained. The presence of gas, however, is definite evidence of either a fistula, an incompetent sphincter, or emphysema from bacterial action—a very rare occurrence. We have seen one case of the latter type, and here the bubblelike character of the gas shadows permitted a ready differentiation. It is notable that gas may be detected in the gallbladder films of cases in which efforts to produce a barium filling of the biliary system have failed. It is advisable to make the examination in both the anteroposterior and posteroanterior positions, as the gas will occasionally be observed in one when not seen in the other. The presence of gas is no doubt the most reliable single sign of a pathologic connection between the biliary system and the intestinal tract.

The second finding is a right paraduodenal accumulation of the contrast media which represents a filling of the gallbladder itself (Figs. 2, 7, and 9). The gallbladder alone or, in addition, the cystic and hepatic ducts, may be demonstrated. Extensive filling of the biliary tree is unusual; more often only the lowermost portion will be seen. Certain procedures greatly facilitate the filling of the biliary system with contrast media. An examination in the prone position with the patient lying on his right side is most likely to produce a filling, following a wave of peristalsis in the duodenum. Reexamination half an hour after the ingestion of the barium meal, during which time the patient has been recumbent and turned on his right side, will also often be effective. The pocket of contrast media seen in these cases must be differentiated chiefly from a duodenal diverticulum. Usually diverticula occur on the mesenteric side of the duodenum rather than on the lateral side, as is the case with barium in the gallbladder. Furthermore, the latter shadow is often irregular, segmented, or stippled

TABLE III

TYPES OF SPONTANEOUS INTERNAL BILIARY FISTULA REPORTED DIAGNOSED BY
ROENTGEN EXAMINATION

AUTHOR	NUMBER OF CASES	YEAR	AUTHOR	NUMBER OF CASES	YEAR
1. Cholecystoduodenal			4. Cholecystocolic		
Hunt-Herbst	1	1915	Judd-Burden	1	1925
Carman-Miller	1	1917	Reich	1	1929
Shoup	1	1917	Schinz	1	1932
Busi	2	1921	Lönnblad	1	1932
Havlicek	1	1925	Prévôt	1	1933
Tandoia	1	1925	Vorhaus-Rogers	1	1934
Habbo-Smith	1	1926	Podlasky	1	1934
Haenisch	1	1926	Blefari-Melazzi	1	1934
Gavazzeni-Lusso	1	1928	Candel-Wolfson	1	1935
Friedrich	1	1929	Medelman	1	1936
Harding	1	1929	Total	10	
Martinotti	1	1929	5. Cholecystogastric		
Ohnell-Lindbloom	1	1929	Smith	1	1928
Dalsace	1	1930	Rankin	1	1932
Buisson	1	1931	Pohlandt	1	1934
Crane	1	1931	Total	3	
Delhern	1	1931	6. Cholecystoduodenocolic		
Gräberger	1	1931	Fuller	1	1931
Jenkinson-Brouse	1	1931	7. Cholecystojejunal		
Lenarduzzi	1	1931	Fraticelli	1	1931
Lust	1	1931	8. Choledochocolic		
Beutel	1	1932	Meese	1	1935
Cristofanetti	1	1932	9. Biliary-Bronchial		
Frugoni	1	1933	Kopáry	1	1928
Sickels-Hudson	1	1934	Cannavo-Cola	1	1931
Paul	2	1934	Laird-Wilkerson	1	1932
Blefari-Melazzi	1	1934	Razemon	1	1933
Kaiser	1	1934	Total	4	
Schéle	1	1935	10. Types of Artificial (Postoperative) Biliary Fistula Demonstrated by Roentgen Examination		
Total	31		Cholecystoduodenostomy		
2. Regurgitation Into Common Duct			Caso	2	1916
Stephenson	1	1921	Hoseman	3	1923
Beall-Jagoda	1	1921	Prevot	1	1923
McArthur	1	1923	Lenk	1	1925
Fishbaugh	1	1926	Odishcharia	1	1929
Sighinolfi	1	1926	Friedrich	1	1929
Venables-Briggs	2	1929	Parade	1	1930
Davis	2	1929	Gräberger	2	1931
Johannesson	2	1929	Schinz	1	1932
Reiman	1	1930	Sickels-Hudson	1	1934
Jenkinson-Brouse	1	1931	Total	14	
Nemours Auguste-			Cholecystogastrostomy		
Jahiel	1	1932	Ralphs	1	1922
Rees	1	1933	Gulecke	1	1923
Engels	1	1934	Mallet-Guy-Beaupere	4	1926
Total	16		Hutter	2	1927
3. Choledochoduodenal			Von Orth	1	1928
Berg	1	1926	O'Bannon	1	1928
Alberti	1	1927	Rybak	1	1931
Kantor-Jaffin	2	1928	Béclère	2	1934
Fraticelli	1	1931	Total	13	
Kern	1	1931	Choledochoduodenostomy		
Meldolesi	1	1932	Swalm-Manges	1	1929
Lewin	1	1932	Fetzer	1	1930
Lönnblad	1	1932	Westphal	1	1930
Arntzen	1	1932	Walters-Thiessen	1	1934
Mardersteig	1	1933	Total	4	
Lamarque	4	1934			
Bignami-Agati					
Total	16				

TABLE IV--CONT'D

CASE	CHIEF COMPLAINT ON ADMISSION	CLINICAL DIAGNOSIS	FIRST ROENTGEN SIGN NOTED	FINAL ROENTGEN DIAGNOSIS	SURGICAL OR AUTOPSY FINDINGS
5	1. "Foamy" diarrhea, 2 yr. 2. Weight loss 100 pounds 3. Gastric distress one-half hour after eating	Carcinoma of pancreas or bile ducts	Gas in bile ducts	Biliary-intestinal fistula (exact type indeterminate)	
6	1. Gastric distress 2. Weight loss 30 pounds in two months 3. Five-year history of gallbladder attacks	Chronic cholecystitis	Barium filling of common duet	Regurgitation through incompetent common duet sphincter: (1) regurgitation through common duet into hepatic ducts. (2) Mucous membrane changes at ampulla	
7	1. Epigastric pain 2. Vomiting	(1) Perforated peptic ulcer. (2) Acute pancreatitis	Gas in bile ducts	Spontaneous biliary fistula, cholecystoduodenal type: (1) Barium in fistula extending to gallbladder. (2) Gas in bile ducts. (3) Mucous membrane changes	<i>Surgical</i> : cholecystoduodenal fistula
8	1. History of gastric distress after eating over a period of forty years 2. Particularly severe attack five months ago, with persistence of pain	Chronic cholecystitis	Extension of barium from duodenum into region of gallbladder	Probable cholecystoduodenal fistula: (1) Direct extension of barium into irregular area, probably gallbladder. (2) Filling of bile ducts with barium	<i>Surgical</i> : cholecystoduodenal fistula

TABLE IV
CASES HEREIN REPORTED OF SPONTANEOUS BILIARY FISTULA ROENTGENOLOGICALLY DIAGNOSED

CASE	CHIEF COMPLAINT ON ADMISSION	CLINICAL DIAGNOSIS	FIRST ROENTGEN SIGN NOTED	FINAL ROENTGEN DIAGNOSIS	SURGICAL OR AUTOPSY FINDINGS
1	1. Epigastric pain 2. Vomiting 3. Chills 4. Fever	Chronic cholecystitis	Gas in bile ducts	Cholecystoduodenal fistula: extension of barium from duodenum directly into upper portion of common duct	
2	1. Abdominal pain (colic) 2. Weight loss 48 pounds in two years 3. Food distress 4. Gallbladder attacks for years	Chronic cholecystitis	Gas in bile ducts	Regurgitation through incompetent common duct sphincter	
3	1. Unusually severe attack of right upper quadrant pain with food distress but without previously noted jaundice 2. Relief of pain in short time, but with onset of persistent vomiting 3. Gallbladder attacks for 31 years	Intestinal obstruction	Barium in gallbladder fossa	Cholecystoduodenal fistula with obstruction due to gallstones: (1) bile ducts and gas in gallbladder, of stones in lower left quadrant. (2) Mass (3) Absence of previously noted stones in gallbladder	<i>Postmortem:</i> cholecystoduodenal fistula with gallstone obstruction
4	1. Vague abdominal distress for several days 2. Sudden severe crampy, colicky abdominal pain, with vomiting	(1) Paralytic ileus (ruptured appendix). (2) Mesenteric thrombosis. (3) Obstruction due to gallstones	Gas in bile ducts	Biliary intestinal fistula with obstruction due to gallstones (exact type indeterminate)	<i>Surgical:</i> obstruction due to gallstones. <i>Post-mortem:</i> cholecystoduodenal fistula

TABLE IV—Cont'd

CASE	CHIEF COMPLAINT ON ADMISSION	CLINICAL DIAGNOSIS	FIRST ROENTGEN SIGN NOTED	FINAL ROENTGEN DIAGNOSIS	SURGICAL OR AUTOPSY FINDINGS
5	1. "Foamy" diarrhea, 2 yr. 2. Weight loss 100 pounds 3. Gastric distress one-half hour after eating	Carcinoma of pancreas of bile ducts	Gas in bile ducts	Biliary-intestinal fistula (exact type indeterminate)	
6	1. Gastric distress 2. Weight loss 30 pounds in two months 3. Five-year history of gallbladder attacks	Chronic cholecystitis	Barium filling common duct	Regurgitation through incompetent common duct sphincter: (1) duct into hepatic ducts. (2) Mucous membrane changes at ampulla	Surgical: cholecystoduodenal fistula
7	1. Epigastric pain 2. Vomiting	(1) Perforated peptic ulcer. (2) Acute pancreatitis	Gas in bile ducts	Spontaneous biliary fistula, cholecystoduodenal type: (1) Barium in fistula extending to gallbladder. (2) Gas in bile ducts. (3) Mucous membrane changes at	Surgical: cholecystoduodenal fistula
8	1. History of gastric distress after eating over a period of forty years 2. Particularly severe attack five months ago, with persistence of pain	Chronic cholecystitis	Extension of barium from duodenum into region of gallbladder	Probable cholecystoduodenal fistula: (1) Direct extension of barium into irregular area, probably gallbladder. (2) Filling of bile ducts with barium	Surgical: cholecystoduodenal fistula

in appearance, while diverticula are smooth and rounded. In addition, folds of mucous membrane may frequently be demonstrated in the neck of a diverticulum, whereas these are obviously absent in the tract of a fistula or even in a dilated common duct.

Changes in the contour of the mucous membrane of the gastrointestinal tract around the stoma of the fistula are regularly present (Figs. 2 and 5). The folds of mucous membrane are irregular and indistinct and show a loss of elasticity. These findings often simulate the mucous membrane change seen in carcinoma. The duodenal bulb, when it is the site of the fistula, shows a constant irregular defect in its contour (Fig. 2), probably secondary to these mucous membrane changes. Partial stenosis of the duodenum may also be present, particularly in the second portion just beyond the duodenal bulb. In the cholecystocolic type of fistula, irregular spastic contraction at the site of the stoma in the colon can usually be made out.

Cholecystographic study, with rare exceptions, shows a nonfunctioning gallbladder. Since cholecystitis is almost always present due either to the original inflammatory condition or to persistence of the infection from regurgitation, the above finding is a most frequent accompaniment of biliary fistula. Negative cholecystograms, therefore, constitute strong evidence against the presence of any fistulous connection.

The various types of fistula have somewhat different characteristics. In general, the distinction is largely based upon the position of the barium-filled fistula in relationship to the gastrointestinal tract and the location of the mucous membrane changes previously described. In the cholecystoduodenal fistula, for example, the usual findings are a right paraduodenal accumulation of barium (Figs. 7 and 9), visualization of a fistulous tract and of the cystic and hepatic ducts filled with air or barium (Fig. 7), a deformed bulb or local mucous membrane changes in the upper portion of the second part of the duodenum, and evidences of a nonfunctioning gallbladder. The findings in this type of fistula are illustrated in the report of Case 3. This case showed, in addition, a gallstone obstruction.

In the choledochoduodenal fistula, there is shown first, a filling of the upper portion of the common duct with barium which extends directly from the duodenum. This is followed by filling of the cystic and hepatic ducts and possibly the gallbladder itself. The following case is reported to illustrate the findings in this type of fistula.

CASE 1.—A woman, aged fifty-four years, was first seen April 26, 1934. She stated that for the past six years she had had recurrent attacks of epigastric pain, vomiting, chills, and fever. During the first attack in 1928, the patient was jaundiced; in the subsequent attacks no jaundice was noted. A cholecystogram on

May 2, 1934, showed a pathologic nonfunctioning gallbladder, and gas could be visualized in the bile ducts (Fig. 1). A gastrointestinal examination on May 7, 1934, showed a deformed duodenal bulb and extension of barium from the duodenum directly into the common duct (Fig. 2). The upper portion of the dilated common duct, and very probably the distal end of the adjoining cystic duct, both filled with barium, could be visualized just above the duodenal bulb. The lower portion of the common duct was not visualized. Roentgen diagnosis: Choledochoduodenal fistula.



Fig. 1.—Case 1. Typical roentgenogram of gallbladder region, showing gas-filled biliary ducts (arrows). Lower arrow points to upper portion of common duct. Note the tubular shape and branching course of the areas of increased radiability representing the smaller ducts.

COMMENT

Gas in the biliary tree indicated a fistula, and the tract between the common bile duct and the duodenum was determined by the barium meal examination. Filling of the upper portion of the common duct, with absence of barium in the lower half is the crucial point in deter-

mining the exact type of fistula. The duodenal irregularity and absence of a shadow of the gallbladder itself are also important points.

The initial attack experienced by the patient was probably associated with biliary obstruction, since the patient was jaundiced. The subsequent absence of jaundice indicates relief of the biliary obstruction. The recurrent chills, fever, vomiting, and pain might well be associated with cholangitis.

The fistula formation probably accounted for the entire picture, since it provided a biliary drainage, yet permitted regurgitation of intestinal contents into the ducts, with the subsequent development

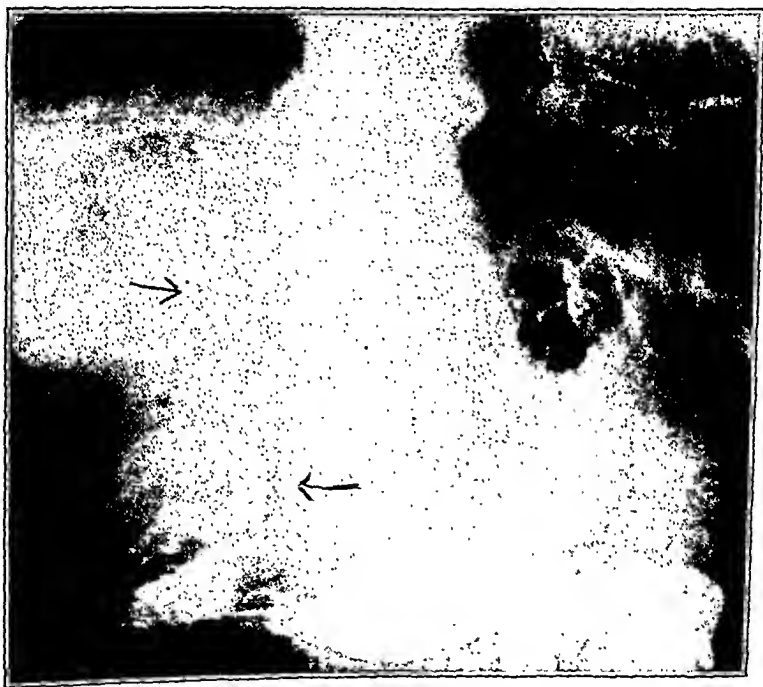


Fig. 2.—Case 1. Roentgenogram after barium meal. Note the barium extending into the dilated, irregular common duct (medial arrow). The cystic duct with barium filling is shown to the right, and the gas-filled hepatic ducts are shown above (arrows). Note the deformity of the duodenal bulb into which the fistula extends. Mucous membrane changes are also present (lateral arrow).

of cholangitis. If regurgitation occurs over a period of years, pathologic changes in the biliary system are a very likely consequence.

When a choledochoduodenal fistula communicates with the duodenum beyond the bulb, it can only rarely be differentiated, by roentgen examination alone, from regurgitation through a wide ampulla and a dilated common duct. In the latter case, the characteristic finding is barium filling the common duct (Fig. 5) at its normal site, beginning medially in the midportion of the second part of the duodenum, about ten centimeters from the pylorus. In the case of a true fistula, in

which there is a communication with the proximal segment of the common duct, this fills directly after the filling of the first portion of the duodenum, and the diagnosis may be readily apparent. When a true fistula, however, has its entrance near the ampulla of Vater, the difficulty of differentiation from other conditions becomes very great. Aside from the possibility of a dilated ampulla producing this finding, there is also the possibility of a true duodenal diverticulum, which may also produce a pocket of barium in this region. Diverticula are very frequently found near the ampulla of Vater, and in an occasional case it may be impossible to differentiate them. Visualization of the common and pancreatic ducts together, in a fork-shaped manner, with rapid emptying after filling, may be observed, if there is a dilated ampulla of Vater. Diverticula are characteristically round and smooth, without any such forking of the neck; usually there is retention of barium for a considerable period of time. The following case is reported to illustrate the roentgen diagnosis of a dilated common duct with regurgitation.

CASE 2.—A woman, aged sixty-seven years, was admitted to the University Hospital on Sept. 28, 1928. The history obtained was typical of chronic gallbladder disease. Subsequent cholecystographic studies showed a large gallstone in the gallbladder (Fig. 3). For various reasons no gallbladder surgery was undertaken at that time. The patient revisited the outpatient clinic with practically the same type of complaints on Feb. 19 and March 26, 1929. She was readmitted on May 13, 1929, at which time the patient reported the passage per rectum of a large gallstone. Previous to passage of the stone the patient had experienced crampy, colicky abdominal pains. She had also noted fatty food distress, and occasionally constipation. After the passage of the stone there was considerable improvement in her condition.

A cholecystogram on Aug. 1, 1929, showed gas in the bile ducts and the previously reported gallstone was not visualized (Fig. 4). Gastrointestinal examination with a barium meal showed regurgitation of the media into the common bile duct (Fig. 5). This formed the basis for the diagnosis of incompetency of the common duct sphincter from passage of a large gallstone.

COMMENT

Gas in the biliary tree indicated the presence of a fistulous connection between the biliary tract and the intestinal tract. The disappearance of the previously demonstrated calculus confirmed this. The exact type of fistula, namely an incompetent common duct sphincter, was demonstrated by barium filling of the common duct. The length of time the common duct sphincter remains incompetent following passage of a stone is indefinite. In this case the sphincter had remained incompetent for at least two and a half months.

Despite the regurgitation of intestinal content into the bile ducts, which undoubtedly occurred, the symptoms were not indicative of cholangitis. This demonstrates the fact that clinical cholangitis does

not invariably result when regurgitation of intestinal contents into the biliary system occurs. Following passage of the stone per rectum, this patient improved quite markedly. She refused operation on the grounds that her general health had improved. If regurgitation continues over a period of years, pathologic changes in the biliary system are practically certain to take place. It then becomes apparent that the cure by fistula formation may be worse than the disease itself.

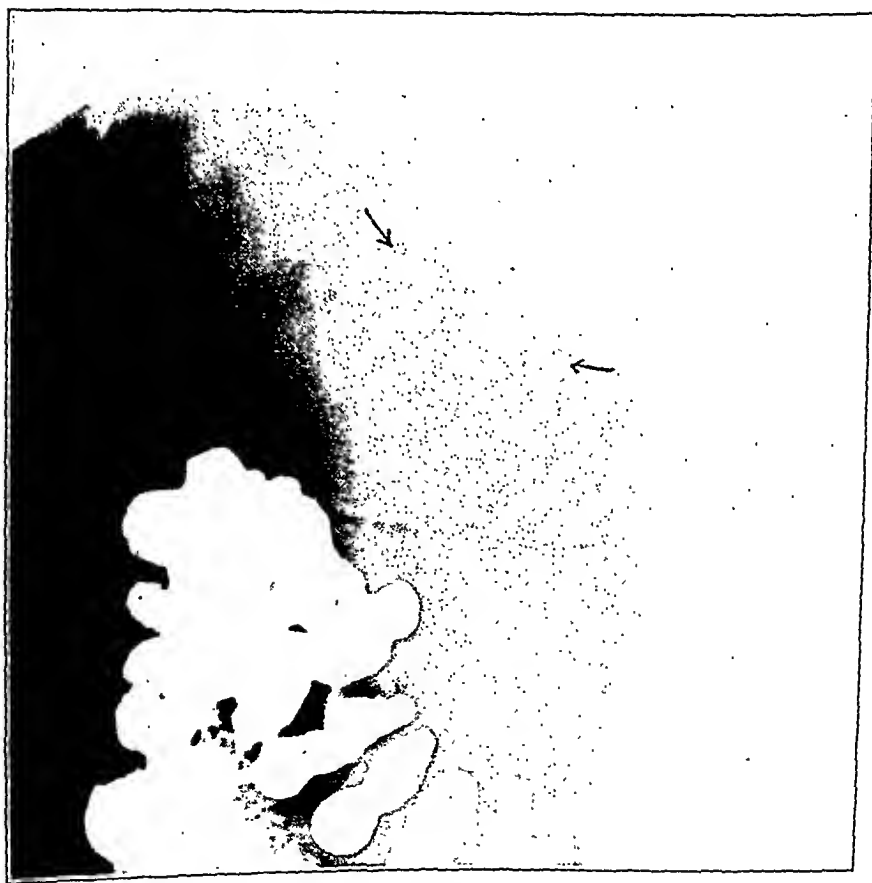


Fig. 3.—Case 2. Cholecystogram made Oct. 9, 1928, showing a single large gallstone (arrows).

In the cholecystocolic type, the fistula practically always joins the colon at the right hepatic flexure. Cases diagnosed by roentgen examination are much more uncommon than the other types, due in part to the difficulty of visualizing the region of the fistula or the gallbladder after the hepatic flexure has been filled with opaque media by the barium enema. With the enema examination the fistulous tract may be demonstrated as the barium or air is forced into it. In addition to this, spasm and irregularity, constriction, and mucous membrane

changes may be seen in the hepatic flexure of the colon. The mucous membrane changes are no doubt of the greatest value in the observation of this type of fistula. The folds will be indistinct, irregular, and often will simulate carcinoma. These changes have been ascribed to

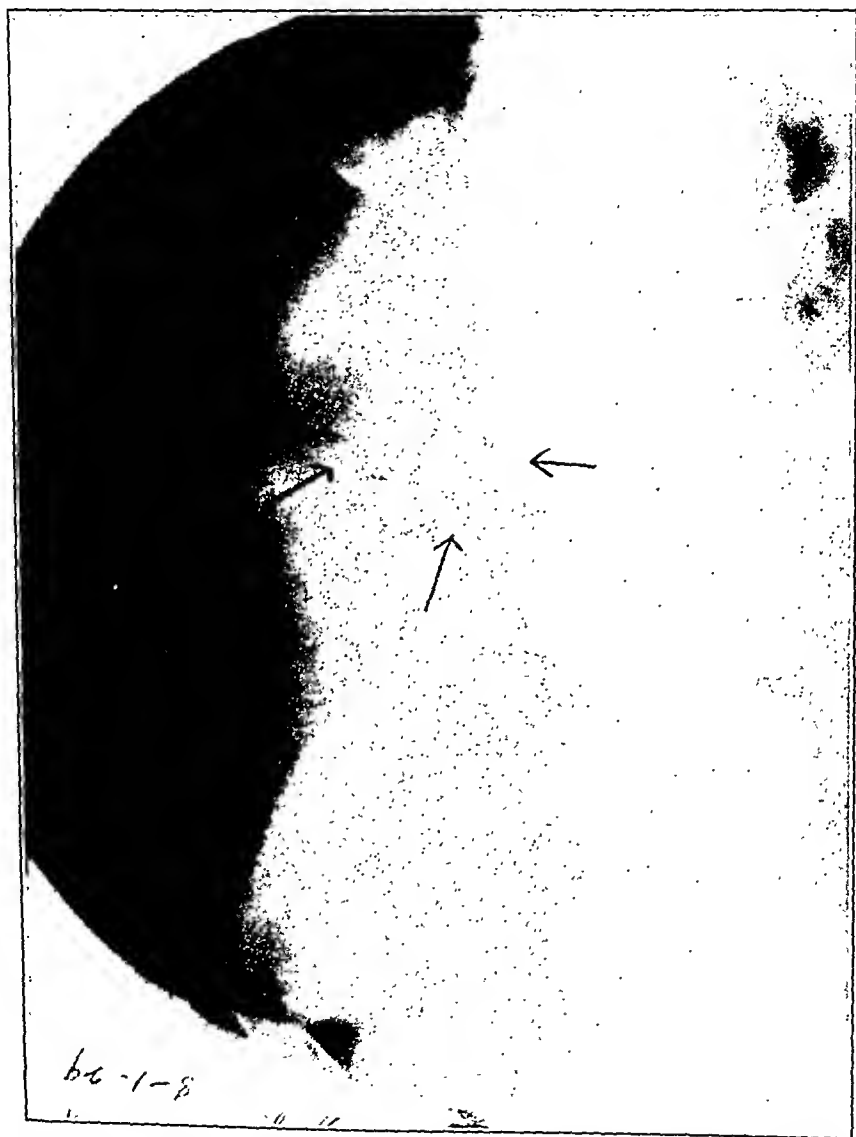


FIG. 4.—Case 2. Cholecystogram made Aug. 1, 1929, after passage of stone. Note the typical appearance of gas in the biliary ducts (arrows). The absence of the stone shadow seen in Fig. 3 should be observed.

the inflow of infected bile. The double contrast enema, that is, the inflation of the colon with air following the evacuation of the ordinary barium enema, is of great value in determining these changes. The barium meal may also be used and the filling of the colon by this

means occasionally reveals the fistulous tract. Here, as elsewhere, gas in the biliary ducts may be the first and only sign of the presence of a fistula.

In the cholecystogastric fistula the demonstration of the barium-filled tract, extending from the prepyloric area to the gallbladder region, is of prime importance. Mucous membrane changes with spasm,



Fig. 5.—Case 2. Roentgenogram after barium meal, showing regurgitation of barium into common duct (arrows), only the lower portion of which is filled. Note the mucous membrane changes in the second portion of the duodenum at the junction with the common duct (lower arrow).

contraction, and constriction of the prepyloric portion of the stomach are also observed. Spontaneous cholecystogastric fistulas are extremely rare. Rankin,²² in 1932, found no reports of this type of fistula in the preceding ten years. His case was discovered when a follow-up examination was made twenty-four hours after the barium

meal, and showed a localized residue in the gallbladder region. Pohlandt's⁸⁸ case became evident when air was visualized in the bile ducts following the administration of dye for a gallbladder study. In the reported cases of this type a direct fistulous connection between the gallbladder and the prepyloric region of the stomach has been present. The exact type of fistula becomes apparent, obviously, when the fistula is filled with the contrast media. An examination one-half to one hour after the ingestion of the barium meal is important, since at this time the fistula may contain barium while the stomach itself has emptied.

Bronchobiliary fistulas are very infrequently found. Oliani,⁸³ in 1923, summarized 63 cases, but only 4 cases have been reported diagnosed by roentgen study. The fistulous tract usually leads from a liver abscess through the right diaphragm and into a branch of the right bronchial tree. Bile in the sputum constitutes the chief clinical finding. Gallstones and hydatid cysts are the usual causative factors. Injection of iodized oil into the bronchi occasionally will outline the fistulous tract. The tract will often heal spontaneously if the stone can be removed.

GALLSTONE OBSTRUCTION—A COMPLICATION OF INTERNAL BILIARY FISTULA

Gallstone obstruction is not an extremely rare condition, as illustrated by the fact that Edward,²⁸ in 1910, had collected 250 cases, Wagner,¹¹⁵ in 1914, had collected 334, and by 1925, Moore⁷⁵ had collected 400 cases. The incidence is indicated by Bennett's⁹ figures in which he showed that in 3,064 cases of intestinal obstruction, 28 were due to gallstones, a percentage of 0.9. In small series, Henry⁴⁴ and Powers⁸⁹ give the incidence at 3.0 per cent and 2.5 per cent respectively. Other authors have estimated the frequency of occurrence of intestinal obstruction due to gallstones as high as 1 in 15 cases (Fitz³²) and as low as 1 in 280 cases (Bloodgood¹⁴). Martin⁶⁹ found only 16 cases of gallstone obstruction in 500,000 patients operated upon. In our own postmortem records there are only 11 cases of gallstone obstruction found in 19,474 autopsies, a percentage of 0.056. It appears from these figures that gallstone obstruction occurs much less frequently than internal biliary fistula. Since over one-half of the gallstones entering the gastrointestinal tract are passed spontaneously per rectum, this disassociation of fistula and obstruction is not surprising. In Judd's⁵¹ series of 153 operated cases of internal biliary fistula, only one case of intestinal obstruction due to stones was found. However, in 11 of the 24 cases of internal biliary fistula found in our autopsies, some intestinal obstruction due to the passed gallstone was encountered. It is obvious that autopsy statistics are likely to show a higher percentage of gallstone obstruction than figures derived from surgical records because of the fatal character of this disease. Stones

usually enter the bowel through the cholecystoduodenal route; in 10 of 11 cases in our autopsies and in 69 per cent of Courvoisier's cases, entrance was gained through this tract.

It should be pointed out again that the finding of gallstone obstruction does not necessarily imply the presence of a true or active fistula. This may be due to a variation in the time of the onset of the obstruction following the entrance of the stone into the intestine. Frequently the length of time elapsing between the passage of the stone into the intestine and the development of the obstruction permit the fistulous tract to heal, only adhesions remaining between the gallbladder and the intestine. Angle² recently reported 1 case in which he estimated the stone had been present in the bowel for one year, and in 2 other cases the obstruction became acute after the stone had been present four months. Treves¹¹² also reported a case in which the gallstone remained in the bowel for ten years.

In addition to this, the possibility of obstruction occurring from the passage of stones through the common duct into the bowel, resulting in a stretched sphincter, but without a true fistula, as stated above, must be considered. Courvoisier²² states that a stone large enough to cause intestinal obstruction occasionally passes through the common duct. In 7 of the 35 cases of intestinal obstruction due to gallstones, cited by him, the route taken by the stone was through the common duct itself. In 1 of these cases the common duct was dilated to the size of the gallbladder; in another, a stone 4 inches in circumference had passed through the common duct resulting in intestinal obstruction. It follows that although the surgeon may be unable to find a true fistulous tract between the biliary system and the intestinal tract, a dilated common duct may indicate the passage taken by the stone. While it is probable that most small stones enter the intestine through the common duct, those large enough to cause obstruction usually enter through a cholecystoduodenal fistula. The physical characteristics are probably more important than the size of the stone in determining the probability of obstruction. A relatively small stone, if sharp and angular, may cause a local spasm of the bowel wall and result in obstruction. This accounts for the cases of gallstone obstruction, terminating fatally, in which small stones have been found free in the lumen of the bowel. Sharp, irregular stones are the most likely to cause local changes in the mucous membrane, resulting in ulceration and perforation of the bowel. In one of the cases of gallstone obstruction in our postmortem records, a faceted calculus, 2.8 by 1.8 cm. in size, resulted in obstruction, causing death of the patient. In the other 10 cases of gallstone obstruction, impaction of the stone had occurred. Smooth, rounded stones, however, even if of considerable size, may pass through the intestinal tract with relatively meager evidence of obstruction. In one case of cholecystoduodenal fistula 2

stones, measuring 4 centimeters in diameter, were found in the small intestine; these, in spite of their size, had not caused intestinal obstruction. Stones entering directly into the colon are nearly always passed per rectum, regardless of size. Rolleston⁹⁷ states that stones over 1 inch in diameter are usually impacted in the small bowel at or near the ileocecal valve, and most authorities are agreed that the majority of obstructions occur in the terminal ileum. Crane²³ has commented on the infrequency of duodenal obstruction by gallstones, having found only 4 cases reported between 1923 and 1931; prior to 1912 Thompson¹¹¹ had found only 12 such cases reported.

Gallstone obstruction occurs most frequently in females, as one might expect. Courvoisier²² studied 102 cases, 69 per cent of which were females; 82 per cent of his cases were over fifty years of age and 61 per cent over sixty years. In 11 cases of gallstone obstruction in our autopsy series all the patients were females and the average age was sixty-six.

The clinical diagnosis of gallstone obstruction is apparently a very difficult one. Characteristically, these cases exhibit a tendency to subchronic or chronic symptoms of obstruction, with periods of more or less obscure abdominal discomfort alternating with periods of relative freedom of symptoms. The pain is ascribed to spasm of the bowel around the stone, and the slow passage of the stone downward produces a clinical course of intestinal colic with unusual variations. The symptoms often are insufficient to cause concern until a few days after the passage into the bowel occurs, and definite signs may be delayed even longer. When the impaction of the stone finally does occur, persistent vomiting with intermittent colicky pain, characteristic of intestinal obstruction, become prominent features. This obscure clinical course often results in delay on the part of the patient in seeking medical advice. Schéle¹⁰⁰ has commented on the unusual period of time elapsing from the onset of symptoms to the admission of the patient to the hospital. The relation of this time factor to the mortality rate is self-apparent. Gallstone obstruction should be thought of in any case in which there is a major abdominal catastrophe and a history of previous attacks of biliary colic. The mortality from this disease has been estimated at from 56 to 92 per cent by various authors,^{44, 69, 74, 75, 78, 103} a much higher rate than in cases of obstruction due to other causes. This is, no doubt, due to the delay in diagnosis incident to the difficulty of estimating the clinical symptoms.

ROENTGENOLOGIC DIAGNOSIS

The preoperative roentgenologic diagnosis of intestinal obstruction due to gallstones has been made in very few cases. So far as we can determine^{15, 27, 52, 63, 66, 86, 100} only 7 such reports appear in the literature. Failure to consider the possibility of biliary calculi as the cause

usually enter the bowel through the cholecystoduodenal route; in 10 of 11 cases in our autopsies and in 69 per cent of Courvoisier's cases, entrance was gained through this tract.

It should be pointed out again that the finding of gallstone obstruction does not necessarily imply the presence of a true or active fistula. This may be due to a variation in the time of the onset of the obstruction following the entrance of the stone into the intestine. Frequently the length of time elapsing between the passage of the stone into the intestine and the development of the obstruction permit the fistulous tract to heal, only adhesions remaining between the gallbladder and the intestine. Angle³ recently reported 1 case in which he estimated the stone had been present in the bowel for one year, and in 2 other cases the obstruction became acute after the stone had been present four months. Treves¹²² also reported a case in which the gallstone remained in the bowel for ten years.

In addition to this, the possibility of obstruction occurring from the passage of stones through the common duct into the bowel, resulting in a stretched sphincter, but without a true fistula, as stated above, must be considered. Courvoisier²² states that a stone large enough to cause intestinal obstruction occasionally passes through the common duct. In 7 of the 35 cases of intestinal obstruction due to gallstones, cited by him, the route taken by the stone was through the common duct itself. In 1 of these cases the common duct was dilated to the size of the gallbladder; in another, a stone 4 inches in circumference had passed through the common duct resulting in intestinal obstruction. It follows that although the surgeon may be unable to find a true fistulous tract between the biliary system and the intestinal tract, a dilated common duct may indicate the passage taken by the stone. While it is probable that most small stones enter the intestine through the common duct, those large enough to cause obstruction usually enter through a cholecystoduodenal fistula. The physical characteristics are probably more important than the size of the stone in determining the probability of obstruction. A relatively small stone, if sharp and angular, may cause a local spasm of the bowel wall and result in obstruction. This accounts for the cases of gallstone obstruction, terminating fatally, in which small stones have been found free in the lumen of the bowel. Sharp, irregular stones are the most likely to cause local changes in the mucous membrane, resulting in ulceration and perforation of the bowel. In one of the cases of gallstone obstruction in our postmortem records, a faceted calculus, 2.8 by 1.8 cm. in size, resulted in obstruction, causing death of the patient. In the other 10 cases of gallstone obstruction, impaction of the stone had occurred. Smooth, rounded stones, however, even if of considerable size, may pass through the intestinal tract with relatively meager evidence of obstruction. In one case of cholecystoduodenal fistula 2

stones, measuring 4 centimeters in diameter, were found in the small intestine; these, in spite of their size, had not caused intestinal obstruction. Stones entering directly into the colon are nearly always passed per rectum, regardless of size. Rolleston⁹⁷ states that stones over 1 inch in diameter are usually impacted in the small bowel at or near the ileocecal valve, and most authorities are agreed that the majority of obstructions occur in the terminal ileum. Crane²³ has commented on the infrequency of duodenal obstruction by gallstones, having found only 4 cases reported between 1923 and 1931; prior to 1912 Thompson¹¹¹ had found only 12 such cases reported.

Gallstone obstruction occurs most frequently in females, as one might expect. Courvoisier²² studied 102 cases, 69 per cent of which were females; 82 per cent of his cases were over fifty years of age and 61 per cent over sixty years. In 11 cases of gallstone obstruction in our autopsy series all the patients were females and the average age was sixty-six.

The clinical diagnosis of gallstone obstruction is apparently a very difficult one. Characteristically, these cases exhibit a tendency to sub-chronic or chronic symptoms of obstruction, with periods of more or less obscure abdominal discomfort alternating with periods of relative freedom of symptoms. The pain is ascribed to spasm of the bowel around the stone, and the slow passage of the stone downward produces a clinical course of intestinal colic with unusual variations. The symptoms often are insufficient to cause concern until a few days after the passage into the bowel occurs, and definite signs may be delayed even longer. When the impaction of the stone finally does occur, persistent vomiting with intermittent colicky pain, characteristic of intestinal obstruction, become prominent features. This obscure clinical course often results in delay on the part of the patient in seeking medical advice. Schéle¹⁰⁰ has commented on the unusual period of time elapsing from the onset of symptoms to the admission of the patient to the hospital. The relation of this time factor to the mortality rate is self-apparent. Gallstone obstruction should be thought of in any case in which there is a major abdominal catastrophe and a history of previous attacks of biliary colic. The mortality from this disease has been estimated at from 56 to 92 per cent by various authors,^{44, 69, 74, 75, 78, 103} a much higher rate than in cases of obstruction due to other causes. This is, no doubt, due to the delay in diagnosis incident to the difficulty of estimating the clinical symptoms.

ROENTGENOLOGIC DIAGNOSIS

The preoperative roentgenologic diagnosis of intestinal obstruction due to gallstones has been made in very few cases. So far as we can determine^{15, 27, 32, 33, 66, 86, 100} only 7 such reports appear in the literature. Failure to consider the possibility of biliary calculi as the cause

of obstruction results in this rarity of roentgen diagnosis. Likewise, the justifiable reluctance in the use of a barium meal by mouth, in cases in which intestinal obstruction is a possibility, often results in the roentgenologist's failure to determine the cause of the obstruction. There can be little doubt that a number of the more obscure cases of ileus are traceable to the presence of a stone in the intestinal tract.

It is well known that from 10 to 20 per cent of the adult population have calculi in the biliary tract, and these frequently enter the intestines. In the past, however, only those cases with stones causing a complete intestinal obstruction requiring surgery have been brought to the surgeon's and roentgenologist's attention. Over 50 per cent of stones, however, do not cause a high grade obstruction, but give rise to some occlusion of varying degree, and finally are passed spontaneously by rectum. In this group, it may be expected that x-ray diagnosis of stones in the intestinal tract will be made with greater frequency in the future.

The chief roentgenologic findings in gallstone obstruction may be due to three factors. The first is concerned with the ordinary signs of the fistula which preceded the obstruction. In this, as outlined above, the most important sign is a visualization of gas in the biliary system. Second, the gallstones themselves may be detected in the roentgenograms of the abdomen. Finally, there is, of course, the roentgenologic evidence of partial or complete obstruction of the intestine.

When the etiology of an intestinal obstruction is in doubt and there is any indication in the clinical story which might implicate the gallbladder, a localized film of the gallbladder region should be made, in addition to the usual abdominal films which are made now with great regularity in cases of intestinal obstruction. If the gallstone is of the opaque type, it may be readily demonstrated either in the gallbladder region or possibly in some remote portion of the abdomen where the obstruction has occurred. Unfortunately, however, some 75 or 80 per cent of the stones which are actually present cannot be well seen in the ordinary films, either of the abdomen or of the gallbladder region itself. The most important sign which will be revealed by these localized films of the gallbladder region is the presence of gas in the biliary system.

In the early stages the obstruction may be high in the intestinal tract, and repeated films of the entire abdomen will show a gradual change in the position of the intestinal gas indicating the changing site of the obstruction. Unusual variations in the degree of intestinal distention with gas may also be noted. In all the cases previously reported in the literature, the patients had a barium meal by mouth

and later showed a circular filling defect in the intestine due to displacement of the contrast medium by the stone. This gives an appearance similar to that of a tumor of the small bowel. Barium meal studies, however, should not constitute a routine procedure in cases of obscure obstruction because of the possibility that the barium itself may increase the degree of obstruction. Careful study of films made

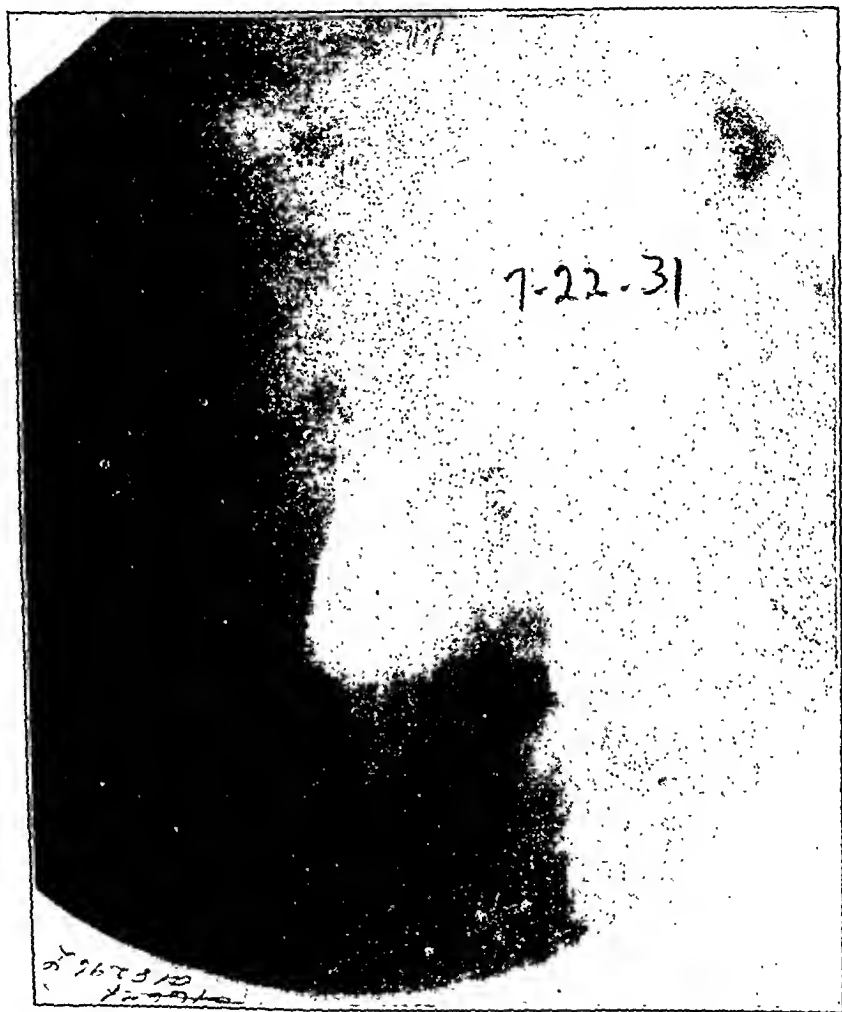


Fig. 6.—Case 3. Roentgenogram made July 22, 1931, showing large mass of typical calcified calculi in gallbladder region.

without contrast media should reveal sufficient findings to make the diagnosis clear. The possibilities of diagnosis and the chief roentgenologic findings are well illustrated in the following case.

CASE 3.—A woman, aged sixty-two years, was first seen in June, 1931. For thirty-one years the patient had had recurrent attacks of right upper quadrant pain with scapular radiation, associated with jaundice, food distress, and occasionally

vomiting. A choleecystogram showed a large number of stones in the gallbladder (Fig. 6). Operation was advised, but the patient refused. The periodic gallbladder attacks continued. On July 15, 1932, the course of events suddenly changed, as the patient suffered an unusually severe attack of pain, and the usual jaundice did not appear. The picture was further complicated by the development of persistent vomiting, which continued until Aug. 11, 1932, when the patient was admitted to the hospital in an extremely toxic and dehydrated condition. The ieterus index upon admission was 12; the stool was positive for urobilin. The clinical im-

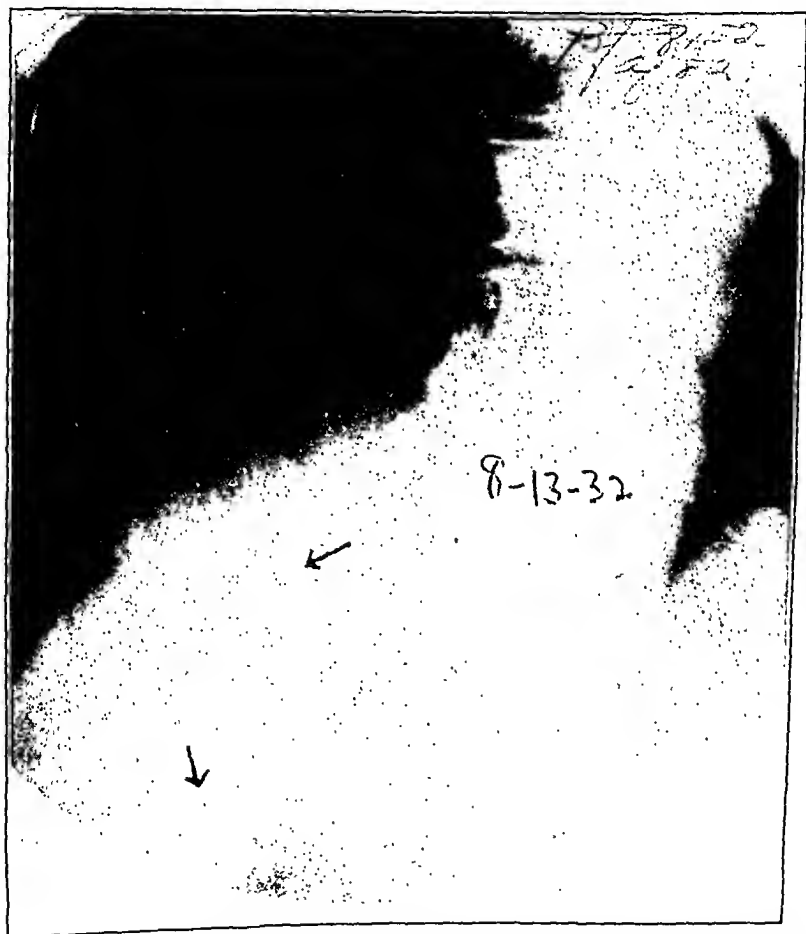


Fig. 7.—Case 3. Roentgenogram made Aug. 13, 1932, showing gas in biliary ducts (upper arrow) and paraduodenal accumulation of barium in gallbladder area (lower arrow). Note absence of gallstone shadows shown in Fig. 6.

pression was pyloric obstruction. A barium meal study of the stomach and duodenum on Aug. 12, 1932, showed a right paraduodenal shadow of barium, rounded in contour, representing what was believed to be the gallbladder. A single film of the gallbladder region on the following day disclosed gas in the bile ducts and absence of the large mass of gallstones previously reported (Fig. 7). Nasal suction was instituted for relief of gaseous distention of the small bowel. Clinical improvement followed, and on Aug. 18, a flat plate of the abdomen revealed a

large mass of stones in the left lower quadrant (Fig. 8). Comparison with the previous film of the gallbladder region revealed a definite similarity to the stones previously visualized in the gallbladder. Gaseous distention of the small bowel was also shown, but the obstruction appeared to be only partial.

A barium meal study of the stomach and duodenum on the next day showed extension of barium from the second portion of the duodenum into a tract leading



FIG. 8.—Case 3. Roentgenogram of abdomen, showing gas in dilated small intestine suggesting partial obstruction. Gas is also present in large amounts in the colon. Note the mass of gallstones, exactly similar to that shown in Fig. 6, in the left lower quadrant (arrows). The diagnosis of internal biliary fistula and gallstone obstruction should have been made from this single film.

into the gallbladder uren (Fig. 9). A rounded barium shadow was visible in the gallbladder region. The roentgenologic diagnosis was: "Biliary fistula extending from the gallbladder fossa into the duodenum formed by the passage en masse of a large number of gallstones, with secondary obstruction of the small bowel due to

vomiting. A cholecystogram showed a large number of stones in the gallbladder (Fig. 6). Operation was advised, but the patient refused. The periodic gallbladder attacks continued. On July 15, 1932, the course of events suddenly changed, as the patient suffered an unusually severe attack of pain, and the usual jaundice did not appear. The picture was further complicated by the development of persistent vomiting, which continued until Aug. 11, 1932, when the patient was admitted to the hospital in an extremely toxic and dehydrated condition. The icterus index upon admission was 12; the stool was positive for urobilin. The clinical im-

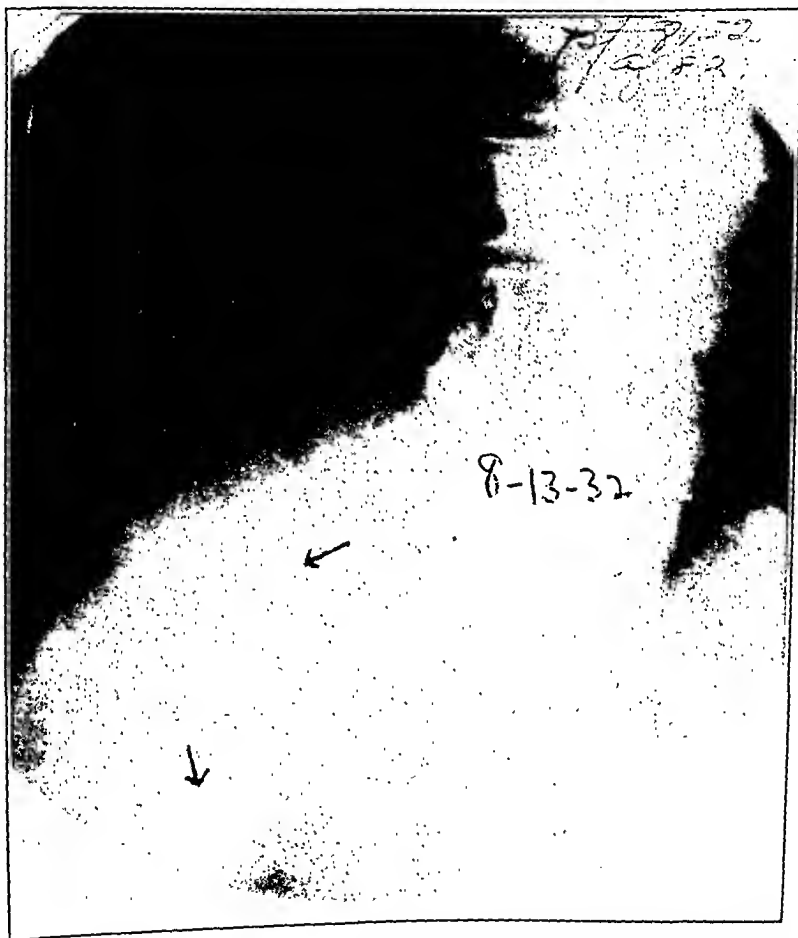


Fig. 7.—Case 3. Roentgenogram made Aug. 13, 1932, showing gas in biliary ducts (upper arrow) and paraduodenal accumulation of barium in gallbladder area (lower arrow). Note absence of gallstone shadows shown in Fig. 6.

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A fistula, the orifice of which was 2 centimeters in diameter, lead into the duodenum. Food particles were present in the gallbladder. The cystic duct was patent; the common duct was thicker than normal and the entire lower one-half was filled with concretions.

A large immovable mass of gallstones was found in the lower ileum firmly filling the lumen of the bowel. There were two sharp projections present, which had caused perforation of the bowel. The stones were firmly matted together by some form of calcareous material. The mass could not be broken apart by moderate manipulation.

COMMENT

The observation of barium in the gallbladder fossa, following the gastrointestinal study, was the first clue to the diagnosis of a fistulous connection between the biliary system and the intestinal tract. Subsequent visualization of gas in the biliary ducts confirmed this diagnosis. The demonstration of the mass of gallstones in the left lower quadrant indicated the diagnosis of gallstone obstruction. Later, following a barium meal by mouth, the fistulous connection to the gallbladder area was visualized, secondary changes in the duodenum were demonstrated, and the intestinal obstruction was confirmed. Absence of the previously visualized mass of gallstones, combined with the clinical story of obstruction, immediately suggested intestinal obstruction due to gallstones. Giving the barium meal was an error and was really unnecessary in making the diagnosis.

The roentgenologic studies explain satisfactorily the clinical course of events in this case. The history of uniform gallbladder attacks with jaundice over a period of thirty-one years, suddenly changing to an unusually severe attack of pain with the absence of jaundice is suggestive of fistula formation. Relative freedom from symptoms thereafter would have been expected in an uncomplicated case of biliary fistula. The rapid onset of an unusual type of intestinal obstruction, however, combined with the long history of gallbladder attacks, and with the occurrence of a major abdominal catastrophe, strongly implies the presence of gallstone obstruction as well as the biliary fistula. A single flat plate of the liver area, showing gas in the bile ducts, would have accounted for the entire picture.

This case is typical of spontaneous internal biliary fistula of the cholecystoduodenal type, with intestinal obstruction due to gallstones as a complicating factor. The passage of a mass of gallstones of this size directly into the duodenum is, however, uncommon. Passage of a mass of this size directly into the colon would be less unusual, and in such an instance obstruction would have been less likely to occur. It is interesting to note that the stones were present in the intestinal tract for two and one-half months. During this time, the original fistulous orifice had contracted considerably and probably would have

the mass of gallstones." Repeated flat plate examinations of the abdomen showed a shifting of the position of the stones (Compare Figs. 8 and 9). After nasal suction, practically no gas was present in the small bowel, and the patient was slightly improved. (The critical condition of the patient did not warrant operation.) Suddenly, on Oct. 2, 1932, two and one-half months after the onset of symptoms of



Fig. 9.—Case 3. Roentgenogram after barium meal, showing typical appearance of cholecystoduodenal fistula. Note paraduodenal accumulation of barium communicating with duodenal bulb. The dilated, obstructed small bowel is well demonstrated (arrow), and the mass of stones can now be seen in the pelvis to the right of the midline (lower arrows).

obstruction, during a period of beginning improvement, the patient experienced severe right lower quadrant pain, with marked tenderness, rigidity, and vomiting. Death occurred Oct. 4, 1932.

Postmortem Examination.—A diffuse purulent peritonitis was present. The ventral surface of the gallbladder, near the fundus, was attached to the duodenum.

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closed at a later date. A smaller stone probably would not have resulted in intestinal obstruction, and the nature of the pathologic process here demonstrated might never have been known.

SUMMARY

The general findings in spontaneous internal biliary fistula are reviewed and the literature is brought up to date. The incidence, pathology, and clinical findings are discussed.

To the previously reported cases observed at autopsy, 24 cases are added.

Eighty-three cases, roentgenologically diagnosed, have been collected from the literature. To these are added 8 new cases.

The roentgen findings in this condition are detailed and 2 cases, roentgenologically diagnosed, are reported in detail. The value of the roentgen examination is emphasized.

The relationship of gallstone obstruction to internal biliary fistula is discussed and the roentgenologic findings are detailed. Seven previously reported cases in which the diagnosis was made by x-ray examination have been collected. To these is added a case of gallstone obstruction with a cholecystoduodenal fistula, roentgenologically diagnosed.

CONCLUSIONS

Spontaneous internal biliary fistula is more common than autopsy or operative records would indicate.

The diagnosis can readily be made by roentgen examination alone and often the exact anatomic site of the fistula can be predicted by this means. The presence of gas or barium in the biliary system, the demonstration of the barium-filled fistula itself, the absence of a normal gallbladder shadow on cholecystography, and the presence of mucous membrane changes in the gastrointestinal tract are the chief roentgenologic findings.

Gallstone obstruction is a complication of internal biliary fistula which should always be considered in atypical cases of intestinal obstruction. It is diagnosed clinically with great difficulty.

Roentgen examination of the gallbladder region particularly, as well as of the whole abdomen, in cases of suspected intestinal obstruction, may reveal evidences of a biliary fistula and thus make the origin of the obstruction clear. This type of examination should be made in all cases with symptoms of obstruction of obscure origin.

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POSTOPERATIVE WOUND INFECTIONS AND THE USE OF SILK: AN EXPERIMENTAL STUDY

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CLINICAL experience has shown that in clean wounds postoperative infection occurs less frequently where fine silk has been employed as suture material than where catgut has been used.¹⁻³ This difference may be attributed to the fact that silk is much less irritating to the tissues and does not itself provide a favorable medium for the growth of bacteria. The silk wound is thus better able to tolerate a slight bacterial contamination which might in the catgut wound result in suppuration. The observations and statistics which have led to these conclusions are, however, open to the just criticism that they are necessarily compiled from more or less uncontrolled data. Obviously, we cannot in the clinic deliberately contaminate wounds to observe their resistance to infection; and where suppuration unfortunately follows a clean operation, it is impossible to control the factors which attended the initial contamination.

As the fear of the consequences of infection still constitutes the chief obstacle to a more general adoption of the silk technic, it seemed desirable to study more carefully the comparative healing of contaminated silk and catgut wounds. We have, therefore, investigated this problem in the experimental laboratory and have been able to demonstrate by controlled observations the superior resistance of silk wounds to infection. We have, likewise, been able to confirm an observation previously made in the clinic,³ which is contrary to accepted opinion; namely, that suppurating silk wounds may in certain instances completely heal without the removal or the spontaneous discharge of the fine silk sutures and ligatures.

METHOD

Healthy dogs were anesthetized with intravenous nembutal, and the usual hospital operating room technic was followed. Two abdominal incisions were made on either side of the midline through the fascia and muscle to the peritoneum. A measured amount of a bacterial suspension was introduced into both wounds and closure made in layers uniformly using silk on the right side and catgut on the left side. On the silk side, interrupted C silk (No. 9) was used for the fascia and interrupted A silk (No. 4)* for the subcutaneous layer and for ligating vessels. On the cat-

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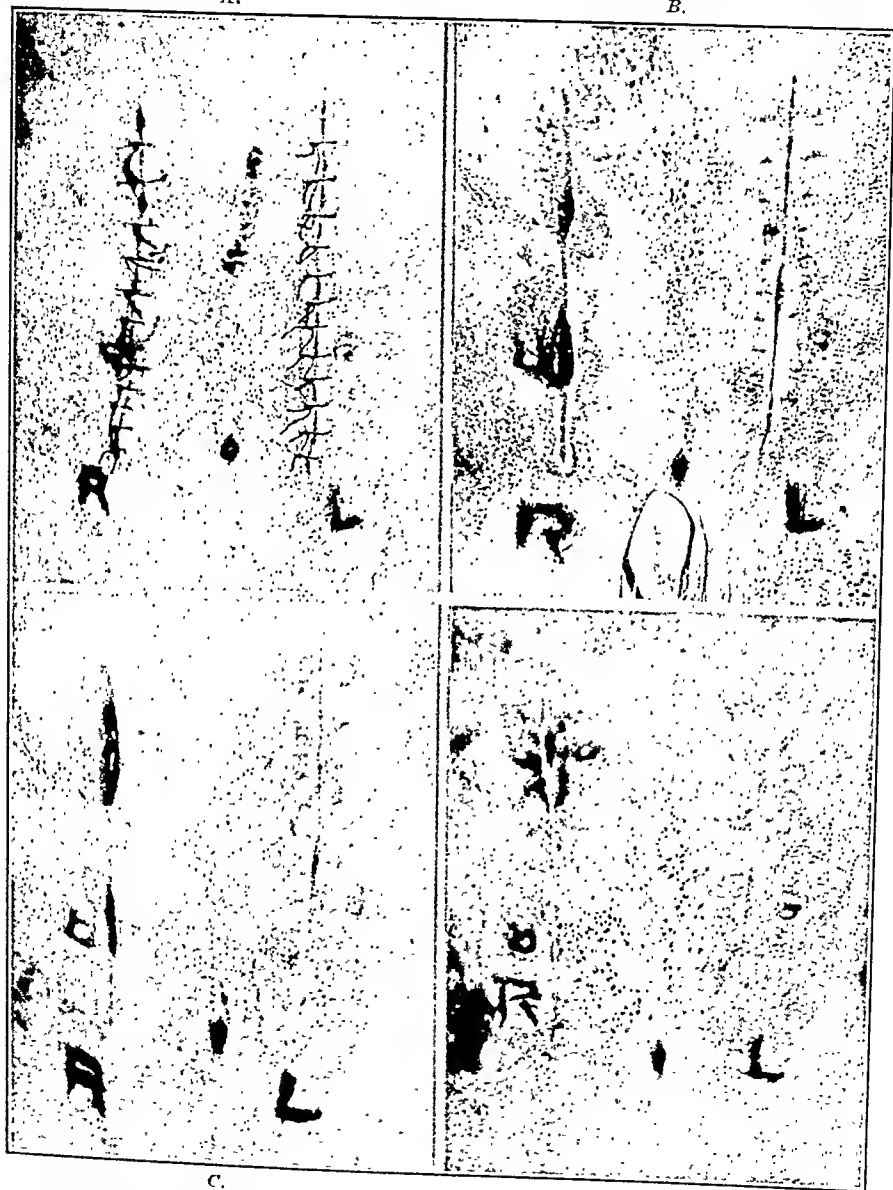
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hypodermic needle. Variations in the procedure were made in several of the experiments. In one experiment *Staphylococcus aureus* was used and in another, a mixture of *Staphylococcus aureus* and *Streptococcus hemolyticus*. During the period of healing, the wounds were protected with dressings. When a wound became distended with

A.

B.



C.

D.

Fig. 2.—Photograph showing the comparative healing of infected wounds sutured with catgut on the right side (left side in photograph) and with silk on the left side. A, on the first postoperative day; B, on the second postoperative day; C, on the fifth postoperative day; D, on the eighteenth postoperative day. The wound sutured with catgut broke widely open and discharged a thick purulent exudate; whereas, the wound sutured with silk showed only slight separation of the wound edges and did not suppurate. Note the contrast (D) between the almost invisible wound on the left side (right side in photograph) and the scarring on the right.

gut side, interrupted No. 1 chromic was used for the fascia and interrupted No. 00 chromic* for the subcutaneous layer and for ligatures. The skin was sutured with silk on both sides. In a number of dogs, the incisions were extended through the peritoneum which was closed before introducing the bacteria. In these, the peritoneum was, as a rule, closed by a continuous suture of No. 00 chromic catgut on the silk side as well as on the catgut side. In two experiments, however, the peritoneum on the silk side was closed by a continuous suture of C silk. As we shall see later, the use of a continuous silk suture in the presence of infection proved to be undesirable.

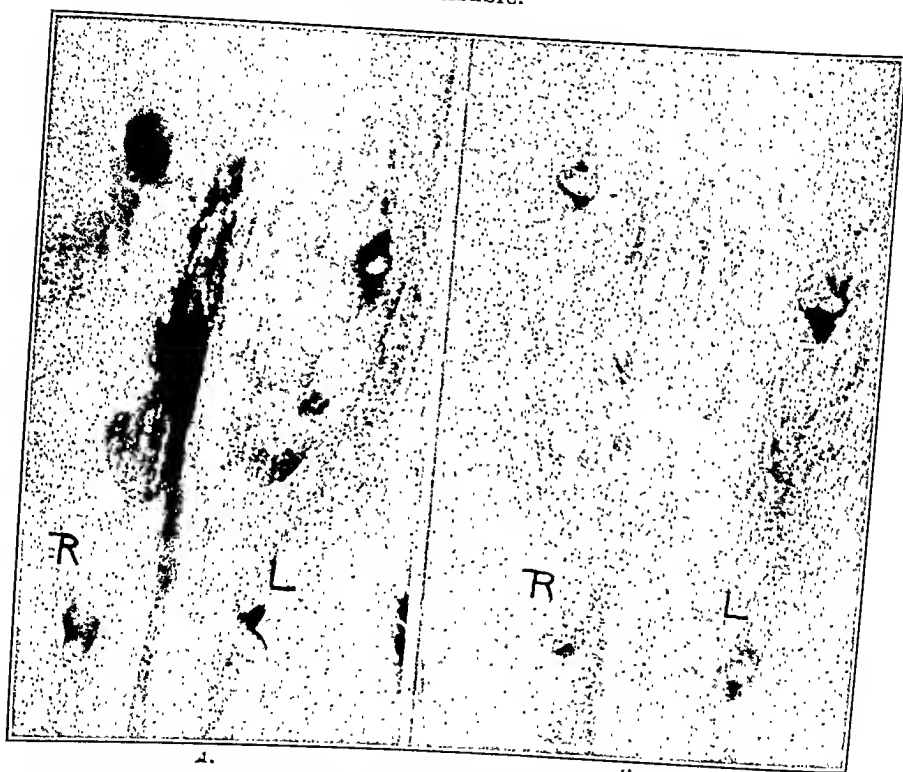


Fig. 1.—Photograph showing the comparative healing of infected wounds which have been sutured with catgut on the right side (left side in photograph) and with silk on the left side. *A*, on the fourth postoperative day; *B*, on the twenty-first postoperative day. The catgut wound broke widely open and discharged a thick purulent exudate. The silk wound, although it became red and swollen, did not suppurate. Postmortem dissection three months later showed the silk sutures in place without gross evidence of infection.

A convenient and effective method of infecting the wounds was the introduction of a suspension of the animal's feces which was obtained from the rectum before the operation. This was mixed with water and strained through gauze. Care was taken to inoculate both wounds equally and simultaneously by a measured amount of the well-mixed suspension applied on the surface of the open wounds through a small

*"Bollable Germicidal Catgut," Davis & Geck, Inc.

RESULTS

The comparative healing of heavily infected silk and catgut wounds was studied in ten experiments. Gross suppuration occurred in the catgut wound in every instance; whereas, the silk wound in four experiments healed without suppuration (Figs. 1 and 2). In four experiments, the silk wounds suppurated, but the wounds showed considerably less reaction than the corresponding catgut wounds, and the suppura-



Fig. 4.—Photomicrograph of a heavily infected wound which was closed in layers with fine silk sutures, four months after operation. Gross suppuration occurred but healing was not delayed by discharge of sutures, and there were no persistent sinuses. Note the well-encapsulated black silk suture (A) and the almost invisible scarring of the line of incision ($\times 12$).

tion occurred at a later date (Fig. 3). In the remaining two experiments, both the silk and the catgut wounds showed about the same reaction and both suppurated at about the same time.

We were particularly interested in following the healing of the silk wounds in which suppuration occurred. All except one of them healed as quickly as the corresponding catgut wound, the average period of healing being twenty-five days. The single exception was one of the two

purulent material, this was liberated through a small opening in the line of the incision. No other treatment was given. The wounds were never opened widely, and no sutures, aside from those in the skin, were removed.



Fig. 3.—Photograph showing the comparative healing of heavily infected wounds sutured with catgut on the right side (left side in photograph) and silk on the left side. A, on the first postoperative day; B, on the third postoperative day; C, on the seventh postoperative day; D, on the twenty-eighth postoperative day. Although the catgut wound showed an earlier and more severe reaction (B), both wounds suppurated. Note that healing occurred just as promptly in the wound containing buried silk as in the wound where catgut was used. Postmortem dissection two months later showed the silk sutures in place with very little reaction of the surrounding tissues and with no gross evidence of infection.

twenty-eight days and remained healed as long as observed for intervals up to twelve months. Seven of the wounds were dissected postmortem. The silk sutures and ligatures were found in place with little or occasionally with no gross tissue reaction. Those in the muscle showed no reaction, whereas, the bits of black silk in the fascia and subcutaneous tissues were frequently found to lie in a tiny area of fibrosis or of yellowish jellylike material. In no case, however, was an abscess found. In one experiment, aerobic and anaerobic dextrose broth cultures were made from the tissues about the silk sutures twelve months postoperatively. No growth was obtained.

Histologic studies of the silk wounds, which were heavily infected, gave definite evidence that satisfactory healing had occurred without discharge of the silk sutures (Figs. 4 and 5).

In one of the experiments, the postmortem dissection disclosed an interesting finding. Both the silk and the catgut wounds had supplicated and healed. Seven weeks later the animal was sacrificed. The silk wound showed all the sutures in place with a small amount of the jellylike material about several of them, but, no fluid or purulent material. The catgut wound, however, contained three indurated areas 5 millimeters in diameter lying in the subcutaneous layer, each containing a small firm catgut knot lying in cloudy fluid. The catgut did not appear altered by its two months' residence in the tissues. Apparently catgut may occasionally, even in the presence of infection, resist absorption and remain unchanged in the tissues for a considerable period. This concurs with our clinical experience, for we have observed several instances in which complete healing has been delayed by bits of unabsorbed catgut.

CONCLUSIONS

1. Controlled experimental studies on dogs show that operative wounds repaired with silk tolerate bacterial contamination better than similar wounds repaired with catgut.

2. The healing of experimental suppurating wounds is not appreciably delayed by the presence of buried silk sutures and ligatures provided a fine grade of silk is used, the sutures are cut close to the knot, and no continuous sutures are employed.

3. Experimental suppurating wounds repaired with fine silk may heal completely without the removal or the spontaneous discharge of the silk sutures.

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instances in which a continuous silk suture was used to close the peritoneum. In this case, a small sinus persisted for seven months, at which time the animal was sacrificed and dissection of the wound showed a long suture lying at the bottom of the sinus. The fine interrupted silk sutures, however, were all in place and were not in communication with the sinus.



FIG. 5.—Higher magnification of the encapsulated silk suture shown in Fig. 4. Although there are still polymorphonuclear leucocytes present, the strands of silk are surrounded by fibroblasts and mononuclear cells ($\times 900$).

There were eight* silk wounds in which suppuration occurred. All of these, with the exception of the above instances, healed firmly within

*In addition to the six suppurative wounds out of the series of ten experiments mentioned previously, there were two wounds in a secondary experiment, both sutured with silk and both heavily inoculated with feces.

twenty-eight days and remained healed as long as observed for intervals up to twelve months. Seven of the wounds were dissected postmortem. The silk sutures and ligatures were found in place with little or occasionally with no gross tissue reaction. Those in the muscle showed no reaction, whereas, the bits of black silk in the fascia and subcutaneous tissues were frequently found to lie in a tiny area of fibrosis or of yellowish jellylike material. In no case, however, was an abscess found. In one experiment, aerobic and anaerobic dextrose broth cultures were made from the tissues about the silk sutures twelve months postoperatively. No growth was obtained.

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PNEUMOCOCCUS PERITONITIS*

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A SURVEY of various reports in the literature reveals considerable discrepancy in the various features of pneumococcus peritonitis, even in the consideration of such important features as treatment. Some authorities advise immediate operation in the early stage of the disease, whereas others prefer to wait until the infection has become localized to an encapsulated abscess. There is likewise disagreement as to the diagnostic difficulties encountered; a great part of this difficulty is no doubt accounted for by the marked variability in the clinical manifestations of the disease. Because of the above features, a study of the available cases† (twenty-six including those accompanied by nephrosis) has been made.

ANALYSIS OF CASES

Search through the records of the medical and surgical service of the St. Louis Children's Hospital during an eighteen-year period has revealed a total of 26 children with pneumococcus peritonitis. They may be divided into three groups as outlined in the following table:

TABLE I

	TOTAL NO.	DIED	SURVIVED
Peritonitis developing in the absence of demonstrable primary lesion	9 { 7 F 2 M	4	5
Peritonitis presumably secondary to upper respiratory infection	7 { 6 F 1 M	3	4
Peritonitis developing in presence of ascites due to nephrosis	10 { 5 F 5 M	7	3
Total mortality 54 per cent. Mortality exclusive of nephrosis group, 44 per cent.			

In the first group of 9 patients, the infection developed in children who were presumably entirely healthy until the manifestations (consisting primarily of abdominal pain, vomiting, and fever) of peritonitis were noted. Contrary to the observations of many authors on the subject of pneumococcus peritonitis, these children did not appear to belong to a lower strata of society, and seemingly had the advantage of

*Credit is extended J. B. Jones who assisted in assembling data on many of the patients.

†These patients represent cases of pneumococcus peritonitis observed in the St. Louis Children's Hospital over a period of 18 years. Sincere thanks are extended to Dr. A. F. Hartmann for the privilege of including many cases from the medical service.

average living quarters. In the second group, the type of upper respiratory infection which preceded the onset of peritonitis by one to six days was variable, but consisted chiefly of pharyngitis and coryza as is noted so consistently in the so-called "common cold." Although pneumonia developed in 4 of these 7 cases, only in one instance did the pneumonia appear to develop before the peritonitis. In the group of 10 children with ascites due to nephrosis, the infection was ushered in rather suddenly with fever, abdominal pain, vomiting, often diarrhea, but seldom with any premonitory symptoms. Of the entire group of 26 cases, 14 died—a mortality of 54 per cent. As has been noted by other observers, however, the mortality in children with nephrosis with superimposed pneumococcus peritonitis is higher than in those who were healthy at the time of contracting the peritonitis. The mortality exclusive of those with nephrosis was 44 per cent.

This series of patients is too small to determine the relative merit of, or damage sustained by, operation in the early stage of the disease. Operation was performed in the early stage only in four instances; on each occasion the operation was performed on the assumption that appendicitis or early peritonitis was present; the correct diagnosis was not made until the abdomen was opened. Operation was not performed on any of the patients with nephrosis. Of the 4 children operated upon, 2 died. This mortality of 50 per cent is undoubtedly misleading, because this group of 4 patients, in reality, represented milder cases than the average. It has been our experience that, when the disease starts locally simulating appendicitis, the infection is less severe. Five children were operated upon because of the development of a local abscess, several days or a few weeks after the onset of the disease. All of these patients survived, indicating that if the patient survives the acute stage of the disease, recovery is to be expected even though abscesses develop, as they commonly do.

Routine cultures of the vaginal tract were not made, but a vaginal discharge was noted in only one child. In this instance, however, the vaginal discharge did not appear until several days following the onset of manifestations of peritonitis. Culture revealed pneumococci in the discharge.

Data regarding the typing of the organism were not obtainable in all cases. The incidence of Group IV organisms was slightly greater than Type I. The mortality in the group of cases with Group IV organism was slightly greater than with Type I. Antipneumococcus serum was used in several instances with evidence of favorable effect in only a few cases. This form of treatment will be discussed later in greater detail.

Diarrhea was a common manifestation (being noted in 30 per cent of the patients exclusive of the nephrosis group), and with few exceptions occurred early in the disease. In fact, on one or two occasions it preceded other manifestations so definitely as to be seriously considered as a possible factor in the pathogenesis.

The tendency toward spontaneous perforation of the abdominal wall at the umbilicus has been noted by numerous observers. In this series of patients the infection broke through the umbilicus with discharge of pus on four different occasions, but did not occur in the nephrosis group.

INCIDENCE

Pneumococcus peritonitis is not a common disease, but occurs frequently enough to demand a thorough knowledge of the subject by the surgeon, as well as the pediatrician. During the eighteen-year period at the St. Louis Children's Hospital when 26 cases were encountered, there were 445 cases of acute appendicitis. The disease is therefore only 4.5 per cent as common as acute appendicitis in this particular locality. It is apparently much more common in Germany and France, judging from the number of cases reported from the various clinics there. Female children between the ages of two and ten years are most commonly afflicted.

PATHOGENESIS

There are three prominent possibilities as portals of entry for the organism. Each of these avenues of infection has its proponents in the literature.

1. The theory of blood-borne transmission is undoubtedly an important one. Of the group of children whose peritoneal infection seems to have developed in this manner, upper respiratory infection (particularly rhinitis, tonsillitis, and pharyngitis) appears to be the most common portal of entry for the organism. In the present series of cases, almost half (exclusive of the cases developing in the presence of nephrosis) gave a history of a significant infection of this type, preceding the onset of peritoneal symptoms by one to five days. In a series reported by Lipschutz and Lowenberg,¹ they noted that 90 per cent gave a history of upper respiratory infection preceding the abdominal symptoms. In a large percentage of their cases and in other series as well, the same type of pneumococcus has been isolated from the throat of the patient as was found in the peritoneal cavity. Montgomery² has emphasized the invalidity of the argument that since the disease is so uncommon in pneumonia, it cannot be blood-borne, by remarking that "metapneumonic joint infections are also rare but they are undoubtedly due to infection from the blood stream."

2. Because of the proximity of the intestine to the peritoneal cavity, transmission of the organism from this source would appear likely, particularly since diarrhea is such a constant accompaniment of the manifestations of the disease. Diarrhea was noted in 30 per cent of the author's series, but in other series it has been reported in a much higher percentage. The most serious obstacle in this theory of transmission lies in the fact that the diarrhea so frequently develops the day

following the onset of peritoneal symptoms. *Pneumococcus peritonitis* has been produced on numerous occasions in animals by feeding cultures of pneumococci by mouth, but there is a sufficiently large number of failures to make the theory unconvincing.

3. McCartney and Fraser³ have presented evidence to prove that transmission by the genital route occurs commonly. In their series of 56 cases, all but 12 were girls. They remark that in every instance of infection in the male, a primary source (pneumonia in 11 of the 12 cases) of infection was demonstrable. They also noted that their patients came from a low stratum of society, and assumed that uncleanness was an important factor in contamination of the vagina with transmission upward into the peritoneal cavity through the uterus and tubes. This observation (occurrence in the low social strata) is not confirmed by the reports of many authors, including the present one.

The pathogenesis of infection in children with nephrosis may be somewhat different from that in healthy children. Hartmann⁴ has called attention to the fact that usually these children are those with poor resistance and are frequently afflicted with chronic infection of the sinuses, tonsils, or adenoids, which are apt to harbor the streptococcus or pneumococcus. Since so many of these children are hospitalized, they are naturally exposed, perhaps more than usual, to pathogenic organisms. Because of a low colloidal osmotic pressure of their blood, there is an abnormal tendency for filtration from the blood into the peritoneal cavity, thereby, perhaps favoring the entrance of organisms into the peritoneal cavity. Moreover, since ascitic fluid is such a good culture medium, this would likewise encourage infection.

In summarizing the data on pathogenesis, one is almost forced to the conclusion that the disease may be contracted in more than one manner. Of the three methods of transmission described, it would appear that the first and third are most common. The author is of the opinion that the disease is more often blood-borne, and in a large percentage of cases, the primary source is an upper respiratory infection. Certainly the occurrence of an upper respiratory infection is commonly noted to precede the peritoneal manifestations by a large number of observers. It is agreed by most observers (Pollock,⁵ and others) that in a majority of instances the development of streptococcus peritonitis is dependent upon an antecedent infection of the respiratory tract. If such a means of transmission of infection is possible in streptococcus peritonitis, it seems logical to assume it may apply to many cases of pneumococcus peritonitis, particularly in the children with the history of upper respiratory infection.

Although routine vaginal smears were not made in the present series, a vaginitis was noted in only one instance; in this case the vaginitis developed while the patient was under observation and three or four days after the onset of the disease. Culture revealed a pneumococcus of the

same type as found in the peritoneal cavity. Certainly, transmission through the uterus and tubes is not the only mechanism, else the disease would not be observed in boys. Six of 20 cases reported by Barrington-Ward⁶ were boys. In the author's series of 26 cases, 8 occurred in boys, although in 5 of these boys a nephrosis was present before the disease developed.

There are other possible avenues of transmission, such as spread by way of the lymphatics through the diaphragm, but they do not seem as important as the three mentioned.

PATHOLOGY

The first pathologic response is a hyperemia and edema of the intestine along with the deposition of a sticky, fibrinous exudate over the serosa of the intestine, omentum, etc. Enlargement of the mesenteric lymph nodes is commonly observed. Many authors have noted a hyperemia of the fallopian tubes in a large percentage of cases. After a day or two a thin, cloudy, yellowish-green exudate with numerous flakes of fibrin develops. This fluid may accumulate in huge quantities; at times two or three liters will be encountered at operation. Within three or four more days the fluid thickens, becoming true pus. It may then be quite homogenous (retaining a greenish tinge) but usually contains many large masses of fibrin. It is at this time, i.e., several days after the onset, that the "walling off" process becomes notable. Circumscribed abscesses may develop at any point in the peritoneal cavity. Although some authors have observed abscesses in the pelvis more frequently than at any other site, this is not true in the author's series. Perforation of the abdominal wall at the umbilicus tends to take place regardless of whether or not encapsulation of the pus has developed. In the author's series, perforation took place in 20 per cent of the cases (excluding the nephrosis group). Pneumonia and empyema represent the two most common complications, and when present, may be very important contributory factors toward death.

CLINICAL MANIFESTATIONS

The symptoms noted at the onset of the disease are extremely variable, particularly regarding severity of symptoms. Diffuse abdominal pain is almost always the first symptom complained of. It may be so severe as to completely disable the child in a few hours, or it may be so mild that the child will be up and about for two or three days before becoming bed fast. Vomiting is a constant and early manifestation, except in the mild cases. As a rule the vomiting occurs more frequently than in other types of peritoneal irritation such as appendicitis. Fever is noted early in the disease and may be present before much tenderness or muscle spasm of the abdomen develops. The abdominal pain is usually diffuse but occasionally starts in the right lower quadrant becoming diffuse a few

hours later. Tenderness is particularly apt to be diffuse. If the infection is an extremely fulminating one, diffuse and pronounced muscle spasm will be observed. Usually, the muscle rigidity is only mild; in fact in most instances the spasm is of a "doughy" nature. Distention usually does not occur until the third or fourth day of the disease.

Not infrequently, particularly if the disease is of several days' duration, the demonstration of dullness to the percussion note over the abdomen may be of considerable significance diagnostically, because of the rare occurrence of fluid in such diseases as appendicitis, etc.

A positive blood culture will be obtainable in roughly half the cases, but most commonly is not obtainable until the second or third day of the disease. The organism naturally is of the same type as that found in the peritoneal cavity. Type I and Group IV are most frequently observed, with the latter perhaps slightly more common than the former. Leucocytosis is quite constant and frequently is as high as 30,000 to 40,000.

For reasons previously stated, a large percentage of cases of pneumococcus peritonitis is observed in children with nephrosis. In the author's series, almost 40 per cent occurred in children with nephrosis; this, no doubt, is an unusually high percentage, but recent reports concerning pneumococcus peritonitis have emphasized the association of the two diseases. Streptococcus peritonitis was about as common, however, as pneumococcus peritonitis in this group of children with nephrosis. Tappan⁷ reported 13 instances of pneumococcus peritonitis in 339 cases of nephrosis. When the infection is complicated by nephrosis, the mortality will usually be in the neighborhood of 60 per cent, which is 10 to 20 per cent higher than that encountered in pneumococcus peritonitis alone.

DIFFERENTIAL DIAGNOSIS

With a few exceptions, an accurate diagnosis should be possible if careful study of the case is made. It must be remembered, however, that the severity of onset of the disease is extremely variable. The disease with which pneumococcus peritonitis would be confused most often is acute appendicitis. In the former instance, fever is usually noted early in the disease; in patients with abdominal manifestations localized to the right lower quadrant, the fever is frequently so high as to be incompatible with acute appendicitis with equal abdominal manifestations. Vomiting is apt to be more pronounced in pneumococcus peritonitis than in acute appendicitis. The diffuse character of the tenderness and pain is not noted in acute appendicitis until peritonitis has developed. Occasionally, in pneumococcus peritonitis marked muscle spasm is present but usually the muscle spasm is relatively slight and consists of a "doughy" resistance. The history of an upper respiratory infection preceding the abdominal symptoms, or the presence of a vaginitis in girls, should lead one to suspect pneumococcus peritonitis and not ap-

pendicitis. The demonstration of fluid in the abdominal cavity, in children previously healthy, is another feature pointing strongly to the pneumococcus as the etiologic factor in the peritonitis.

Leucocytosis, on the average, is higher in pneumococcus peritonitis than in lesions such as appendicitis, Meckel's diverticulum, etc. The Hippocratic facies which is so constantly observed in peritonitis due to the *Bacillus coli* is rarely present in pneumococcus peritonitis, and, when it is present, is noted usually only in the terminal stage.

If acute abdominal symptoms develop in a child with a preexisting nephrosis, pneumococcus peritonitis should receive early diagnostic consideration because of the frequency of this association.

The most difficulty in differential diagnosis is usually experienced in discriminating streptococcus from pneumococcus peritonitis. The onset and clinical findings may be quite similar. The majority of cases of streptococcus peritonitis are usually noted in infants; in this disease there is not such a predilection to affect female children. A positive differentiation may be possible only by examination of material obtained by abdominal puncture.

There is considerable dispute about the safety of diagnostic puncture, but definite and proved instances of damage produced by this procedure are lacking. It is, in reality, simply performed, and may yield a positive diagnosis. The skin is treated with iodine and alcohol, a small wheal is made with novocaine, and a tiny slit is made in the skin with a knife. A dull needle with a large bore (e.g., spinal puncture needle) is inserted into the peritoneal cavity and an attempt is made to aspirate. Obviously a quantity as small as a portion of a drop is sufficient to make a smear and gram stain. If short-chained streptococci are the cause of the peritonitis, difficulty may be experienced in differentiating them from pneumococci; positive identification may not be possible until results of culture are known twenty-four hours later. If numerous kinds of organisms, with a predominance of gram-negative bacilli (*B. coli*) are found, the peritonitis may be considered to be of appendiceal origin.

Blood culture is another reliable method of making a positive diagnosis, but is positive in only about half the cases. Moreover, at least twenty-four hours must elapse before the results are known.

TREATMENT

As stated previously, there is considerable difference of opinion regarding the advocacy of operation in the primary stage of the disease. Mortality statistics on operated and nonoperated cases are bound to be misleading, because many of the patients will be so ill that operation will not be considered. This situation would tend to show a comparatively higher mortality in the nonoperated cases than in the operated cases, but would not be an accurate estimation of the value of

operation. As a matter of fact, the statistics* in the series herein reported favor postponement of operation. Of the four patients upon whom operation was performed in the acute stage, two died, a mortality of 50 per cent. Of the remaining 12 (5 of whom were operated upon later for encapsulated abscess), only 5 died, or a mortality of slightly less than 42 per cent. The author is, therefore, of the opinion that operation should be performed only after encapsulation of pus has taken place.

It is a very significant fact that if the child survives the first few days, he is apt to recover. Of the patients in our series who were operated upon for an encapsulated abscess, none died. Apparently, the formation of an abscess is indicative of the development of considerable active immunity.

There is a general agreement among the various observers that anti-pneumococcus serum should be given as in other pneumococcus infections (e.g., pneumonia, etc.). However, there are not many favorable reports in the literature regarding its use. It was used on 7 cases in the series herein discussed, but only in 2 instances was there a definite favorable effect. One patient sustaining a favorable effect was a child with nephrosis; in this instance the effect was so definite as to lead one to believe it may have been the responsible factor in her recovery.

In one of the patients with pneumococcus peritonitis, a girl aged eleven years, in whom a Type I organism was isolated, the titer of her serum for the pneumococcus six weeks after onset of symptoms was higher than the titer of the commercial antipneumococcus serum. Obviously if the titer of the patient's serum approaches that of the commercial serum, its injection could not be expected to have any significant beneficial results.

Other supportive measures including subcutaneous saline and intravenous glucose are usually indicated to maintain water balance and to supply at least a small amount of calories. Transfusions appear to be unusually helpful and should be given to all patients who are seriously ill. During the acute stage of the disease, no food or fluid should be given by mouth.

All of these children must be observed for many weeks, particularly for the development of an intraabdominal abscess. When an abscess forms, it should be drained surgically. It is especially necessary to observe the patients for many weeks even though recovery seems to have taken place, because abscesses have been known to form weeks after the patient was apparently well.

SUMMARY

A study of the cases of pneumococcus peritonitis (26 in number) occurring in the St. Louis Children's Hospital during the past eighteen

*These figures exclude the cases with nephrosis, since none of them were operated upon.

years, has led to certain deductions. In this series, it appears that development of peritonitis secondary to infections, such as those of the upper respiratory tract, is more common than any other mechanism in pathogenesis. The author is of the opinion that the correct diagnosis can usually be made in differentiation from acute appendicitis, by noting such features as early development of fever, profuse vomiting, diffuse character of tenderness and pain, prevalence in girls. Diagnostic puncture of the abdomen is justifiable in children when diagnosis is uncertain, and rarely fails to aid in the establishment of a correct diagnosis if the peritonitis is of pneumococcal origin. For many reasons immediate operation appears to be contraindicated. Although the present series is far too small to allow conclusions regarding this point, the results favor waiting until a localized abscess forms.

It is a striking fact that if the child survives the acute stage of the disease, recovery is almost certain, even though one or more localized abscesses form, provided, of course, such abscesses are properly drained.

Pneumococcus peritonitis is a common complication of nephrosis. The mortality in these children will be higher than in previously healthy children. In this series it was 54 per cent contrasted to 44 per cent in the previously healthy children.

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THE DISAPPEARANCE OF GALLSTONE SHADOWS FOLLOWING THE PROLONGED ADMINISTRATION OF BILE SALTS

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A REVIEW of the end-results of gallbladder surgery seems to indicate that removal of the gallbladder and stones is not the entire answer to this problem. Judd,¹ in analyzing the results of cholecystectomy upon the basis of pathologic changes in the gallbladder, found that when these changes were minimal, the results were satisfactory in 64 per cent of the cases, and when cholecystitis and stones were present, they were satisfactory in 87.8 per cent. In cases of noncalculous cholecystitis, however, Graham and Mackey² reported satisfactory results in only 30 per cent of the cases, and improvement in another 30 per cent in which cholecystectomy had been performed.

It is evident from these reports, as well as from the results of other investigators, that only in the presence of severe symptoms (such as colic) associated with gallstones will removal of the gallbladder give satisfactory results in a large percentage of cases. Even in many of these cases, subsequent investigation will reveal that although these patients are entirely relieved of colic, they continue to suffer from indigestion, food intolerance, and constipation. These results become intelligible when one considers the fact that symptoms in cholecystitis are due to three factors, such as: (1) Infection of the gallbladder; (2) mechanical effects of stones; and (3) disturbances in the bile salt metabolism, which result in indigestion, disturbances in the digestion of fat, and constipation. Cholecystectomy and removal of the stones correct the first two factors, but do nothing about the third. Consequently, there are residual symptoms following cholecystectomy.

A fact established early in the history of bile physiology was the circulation of the bile acids, a rapid adsorption of the bile salts from the intestine with prompt reappearance in the bile. Greene, Aldrich, and Rowntree³ confirmed the enterohepatic circulation of bile acids by showing their presence in the portal blood after oral administration. Bile salt excretion is uniform during the day in spite of a single daily feeding (Smith, Groth, and Whipple).⁴ Daily refeeding of all bile secreted from a fistula raises the bile secretion, but when high levels are attained, the output falls behind the intake. This also occurs when a bile surplus is produced within the body. The disappearance of the surplus and its fate remain a mystery (Smith and Whipple).⁵ The normal daily output of bile salts can be increased by a meat and fish diet and decreased more by a carbohydrate than a fasting diet. This

suggests an exogenous factor influencing bile acid production. An interesting parallel between urinary nitrogen and the bile salt secretion apparently points to an important endogenous factor, probably concerned with body protein metabolism (Whipple).⁶

It is generally thought that the bile acids are produced by the liver parenchyma, since a slight injury to the liver by chloroform will cause a great drop in bile salt output which returns to normal with the rapid



Fig. 1.—Numerous round negative shadows are present in a poorly functioning gallbladder.

repair of the liver cells. Protease intoxication causes a considerable increase in the breakdown of body proteins, and a fall in the output of bile salts. This may be due to the fact that the protease also causes an impairment of liver epithelium as it does to the secretory cells of the kidney. X-ray over the liver causes a fall in the bile salt output, but not as much as ehloroform, protease, or large doses of phosphorus. Infection in other parts of the body and pregnaney also reduce the output of bile salts.

The employment of bile salts in the treatment of liver and gallbladder disease has been regarded as a logical and valuable approach to these cases. In a theoretical consideration of the metabolism and function of bile salts, one finds many factors which support the rationale of their use in the medical management of gallbladder disease.

The functions of bilt salts when they reach the intestine are well known. They aid in the digestion and adsorption of fats; they have

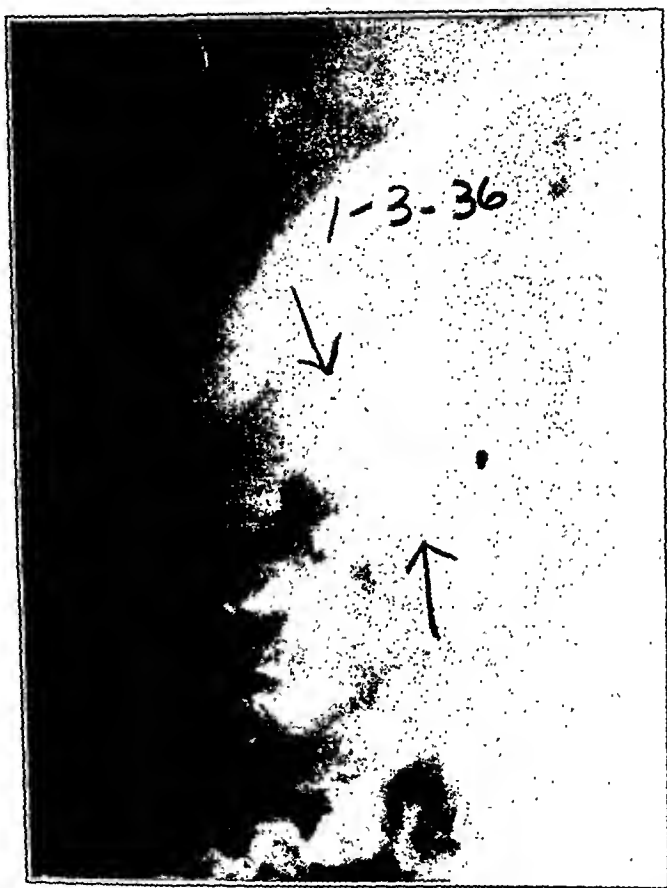


Fig. 2.—Same case 6 months later, after the oral administration of bile salts. Normally functioning gallbladder with no negative shadows present.

been known to stimulate the flow of pancreatic enzymes; and they seem to have a tonic effect on intestinal motility.

Another important rôle ascribed to the bile acids by both Wright and Whipple,⁷ and Andrews and his coworkers is the relation of the bile acids to the metabolism of cholesterol. The recent work of Schoenheimer and Hrdina, 1931,⁸ and Andrews, Schoenheimer, and Hrdina,⁹ (1931a, b, 1931) is significant. They showed that most of the cholesterol of human bile is present in the form of water-soluble complexes with the bile salts.

These complexes are so unstable that when they are subjected to dialysis, the bile salts pass out, and the cholesterol is precipitated. Therefore, it would appear that any disturbance which lowers the ratio of bile salts to cholesterol could cause precipitation. Moreover, analysis showed that bile in cholelithiasis has a much lower bile salt-cholesterol ratio than the bile from bladders not containing stones. If this hypothesis is true, then cholesterol gallstones should disappear if the normal bile salt-cholesterol ratio is restored. The purpose of this investigation then is to study the effect of oral administration of bile salts upon cholesterol gallstones *in vivo*.

A series of known gallstone cases were used in this study. The stones were demonstrated by cholecystograms. These patients were fed three grains of bile salts three times daily. A teaspoonful of olive oil was likewise fed to furnish an adequate stimulus to empty the gallbladder. After a period of nine months, these patients were studied again. The results are given in Table I.

TABLE I

UNIVERSITY HOSPITAL NUMBER	SEX	CASE	AGE	FUNCTION	FIRST X-RAY	SECOND X-RAY
638961	F	1	38	Poor	Numerous negative shadows present.	Normally functioning gallbladder. No stones present.
637599	F	2	46	Fair	Numerous negative shadows present.	Normally functioning gallbladder. No stones present.
638826	F	3	33	Fair	Two large gallstones covered with a calcium capsule.	Gallstones unchanged.
626830	M	4	57	Poor	Two large stones. No dye entered gallbladder.	Gallstones unchanged. No dye entered gallbladder.
640889	F	5	49	Fair	Numerous negative shadows present.	Gallstones unchanged.

Subjectively these patients showed definite improvement. Their digestion was better, they complained of less gas or distention, and they could eat any food without distress. In fact, at the end of the course of treatment, four patients were symptom-free. The last patient, although materially better, continued to complain of discomfort in the upper right quadrant. During the early months of treatment of Case 2, the patient had frequent attacks of colic; as time passed, however, these attacks became less frequent until they disappeared entirely. In Case 1 the patient was symptom-free throughout the entire course of treatment.

A summary of the x-ray findings is of interest, in that in Cases 1 and 2 the gallstone shadows disappear entirely, and a normally functioning gallbladder was the end-result. In Case 4 the gallstones were un-

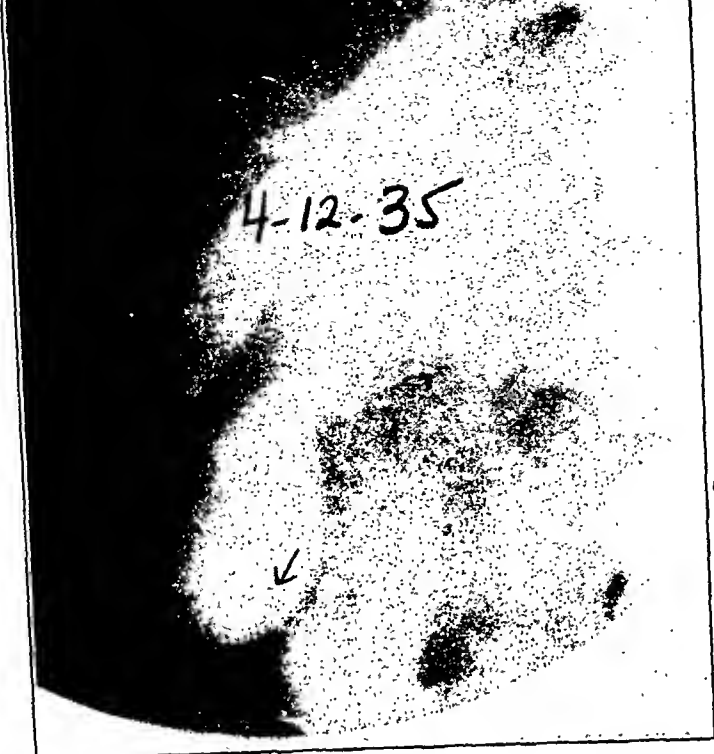


Fig. 3.—Numerous round negative shadows present in a moderately well functioning gallbladder.

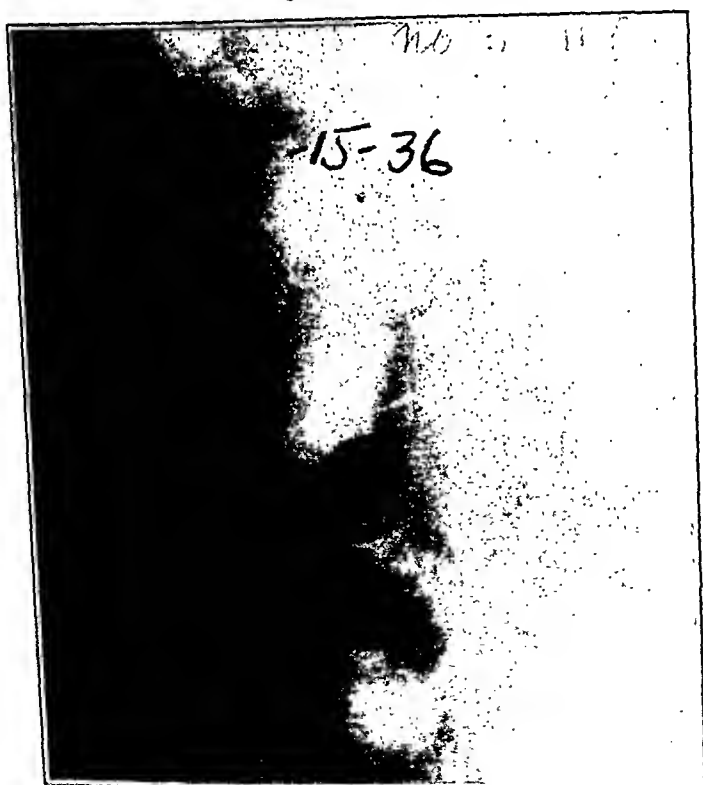


Fig. 4.—Same case 2 months later, after oral administration of bile salts.

changed after treatment. Failure in this case may be explained on the basis that the cystic duct might not be patent, consequently one could not hope for success.

The gallstones in Case 3 were covered with deposits of lime salts. Failure in this case becomes intelligible. There is no apparent explanation for failure in Case 5. Possibly the dose of bile salts was inadequate, and the treatment was not continued long enough.

COMMENT

Rosenak and Kohlstaet,¹⁰ in 1936, and others have reported beneficial subjective effects resulting from the bile salt treatment of patients with diseased gallbladders. The most noted improvement was observed in the control of digestive symptoms and constipation. With their results in mind, bile salt therapy suggests itself as the logical way to treat those residual symptoms which follow cholecystectomy.

In the observations described above, it is believed that the disappearance of gallstones following treatment in Cases 1 and 2 is significant. In both these cases, the end-result was both subjective and objective cure, with a normally functioning gallbladder as the end-result. The possibilities of this method of treatment can be determined only by further study. These observations suggest that the cause of cholesterol gallstone formation is a bile salt deficiency; when remedied, the gallstones disappear.

CONCLUSIONS

1. In cases of cholecystitis and cholelithiasis, subjective relief is obtained by the oral administration of bile salts.
2. Gallstone shadows as demonstrated by x-ray may be made to disappear following prolonged administration of bile salts.
3. The cause of cholesterol gallstone formation is a bile salt deficiency resulting from liver damage.

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TREATMENT OF OSTEOMYELITIS OF THE CRANIAL VAULT

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TREATMENT of osteomyelitis of the cranial vault has been more or less of a hit-and-miss affair until the last few years so far as operative measures are concerned. The mortality rate was very high. The good results which have been obtained by surgeons who have boldly extirpated the full thickness of the skull well beyond the diseased area speak for themselves. They are so much better than those previously obtained. This mode of attack on the diseased bone was not advocated until about twenty-three years ago, and was not seriously carried out until during the last decade. Even now it is not generally appreciated. McKenzie advocated this procedure in his first famous contribution in 1913, and stated that "Once progressive osteomyelitis has set in, the only chance of saving the patient lies in immediate and entire removal of the diseased bone. We can scarcely hope to cure diffuse osteomyelitis by simple drainage, hence limited and partial measures, such as incisions, trephining, etc., are useless." It is remarkable how long it has taken this idea to permeate our own mentalities.

This discussion will consider only the *treatment* of, and surgical principles concerned with, the condition. Etiology, with the pathways of infection, pathology, bacteriology, symptomatology, and diagnosis, will not be dealt with in detail. All, or some, of these phases have been discussed in previous contributions by Adson,¹ Blair and Brown,² Bulson,^{3,4} Campbell,⁵ Connor,⁶ Dabney,⁷ Eagleton,⁸ Fincher,⁹ Fleming,¹⁰ Frey,¹¹ Furstenberg,¹² Gelanze,¹³ Gerber,¹⁴ Hanson,¹⁵ Hastings,¹⁶ Knapp,¹⁹ Lillie,²⁰ Lue,²¹ McKenzie,²³ Marek,²⁴ Mason,²⁵ Meyers,²⁶ Mosher,²⁷ Mosher and Judd,²⁸ Schilling,³⁰ Skillern,³¹ Turner and Reynolds,³² Wilensky,³³ Woodward,³⁴ and other writers. Some of these writers have given detailed and comprehensive review of the literature, while others have stated their own clinical observations and have given reports of cases. Mosher stated that four of the most noteworthy papers which have appeared in recent years on the subject have been those by McKenzie, Bulson, Wilensky, and Furstenberg. I would like to add his name to that list. Since these papers have covered the subject matter so completely, my purpose in presenting this paper resolves

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itself into two objectives: first, to emphasize and accentuate the importance of *complete* operation, and second, to give some clinical observations.

CONSIDERATION OF GROSS PATHOLOGY AND SURGICAL PRINCIPLES

Regardless of whether the initial infection enters a bone of the cranial vault by direct extension from one of the accessory nasal sinuses, the middle ear, or mastoid; by retrograde thrombosis of veins; by thrombophlebitis, retrograde thrombosis and extension through the dura, as suggested by Furstenberg; or by metastasis, the infection is first a local one in the bone, in the majority of cases, and so can be considered from a practical standpoint. Therefore, what could be more logical in combating this otherwise destructive condition than to attack it as early as the diagnosis can be made, and to remove completely the involved area with its source of infection? As was noted by McKenzie, osteomyelitis of the cranial vault very seldom metastasizes to other bones and other organs, in contrast to a similar infection of the long bones. Radical removal should therefore effect a cure. Once it has begun, however, its inevitable tendency is to spread to adjoining portions of the skull and, if untreated, it may run the entire gamut through extradural and subcutaneous abscesses, cortical and subcortical abscesses, thrombosis of major sinuses, generalized involvement of the skull, meningitis, suppurative leptomenigitis, and sepsis, to death.

It is well recognized by all writers that most cases of osteomyelitis of the frontal bone occur in young people and that the infection tends, for a certain period of time, to localize to one side, or at least be confined to one bone. It is believed that the fibrous tissue which exists between the suture lines before complete closure acts as a barrier to the extension of infection, and makes the disease more amenable to eradication.

It is also recognized that the condition frequently begins with stealthy and insidious onset, and that a gross pathologic process, which could and should be removed, exists before the radiographic films show the clear-cut undeniable moth-eaten picture of well-established osteomyelitis. F. W. Law and I have reviewed serial x-ray films of cases of osteomyelitis of the frontal bone. We were impressed with the early differences in the appearance of the two sides of the postero-anterior films. These differences are more apparent when the films are reviewed in reverse. If attention is focused on the region of the frontal bone where the eventual breaking down of bone occurs, one can observe an area of less density in earlier films. This is due to softening and partial decalcification of the area. Evidence of the presence of this area is very questionable in the earliest films, or it

may not exist at all. After a few days, however, a rounded area of less density is visible at the point where the eventual breaking down will occur. This area is probably more noticeable if viewed from a distance of five or six feet than at a short distance. In some instances in our experience, films were made at the time frontal sinusitis or orbital abscess was present and not again until a definite breaking down of the cranial tables with formation of a subcutaneous or an extradural abscess had occurred. The intervals between the x-ray examinations in many instances were surprisingly long. In view of these observations, we advise that a posteroanterior film be made at intervals of every two or three days with the expectation of finding the area of less density which gradually appears several days (about ten days to two weeks) before the typical moth-eaten picture makes its appearance. By so doing, the condition may be recognized, and operation carried out at an earlier date without so much sacrifice of bone. At least, evidence may be sufficient to warrant an exploratory drill hole at the site.

Although osteomyelitis of the skull may spontaneously occur without any instrumentation by the surgeon, it must be acknowledged that a large number of cases follow instrumentation or operation. This is especially true following any operation upon the sinus. It is believed that fewer cases would develop were the sinus operated upon with purely surgical principles in mind, leaving the question of cosmetic result for a later date. Full, open, and prolonged drainage with iodoform gauze packing after a proper operation would allow the sinus to fill up with firm granulation tissue, and completely obliterate the sinus. Future troubles might be avoided. The depressed scar can readily be removed by a minor plastic operation. Mosher holds this view, and Ross Faulkner in a recent conversation gave the same opinion.

PREOPERATIVE MEASURES

General Condition of Patient.—Some patients have already undergone a radical operation on the sinus or multiple operations for sinusitis, orbital abscesses, etc., and are frequently in a run-down and debilitated condition, with loss of weight and strength. As a result the hemoglobin may be low and resistance poor. One or more small transfusions before operation are advisable. At any rate, the patient should be typed and cross typed with a donor held ready for transfusion. In cases of severe spontaneous generalized osteomyelitis associated with pansinusitis, with the patient in a markedly septic condition, only preliminary trephining and aeration of the sinuses should be done. Should a large, extradural lake of pus be present, as evidenced by hemiparesis or hemiplegia, two or three trephine openings should be

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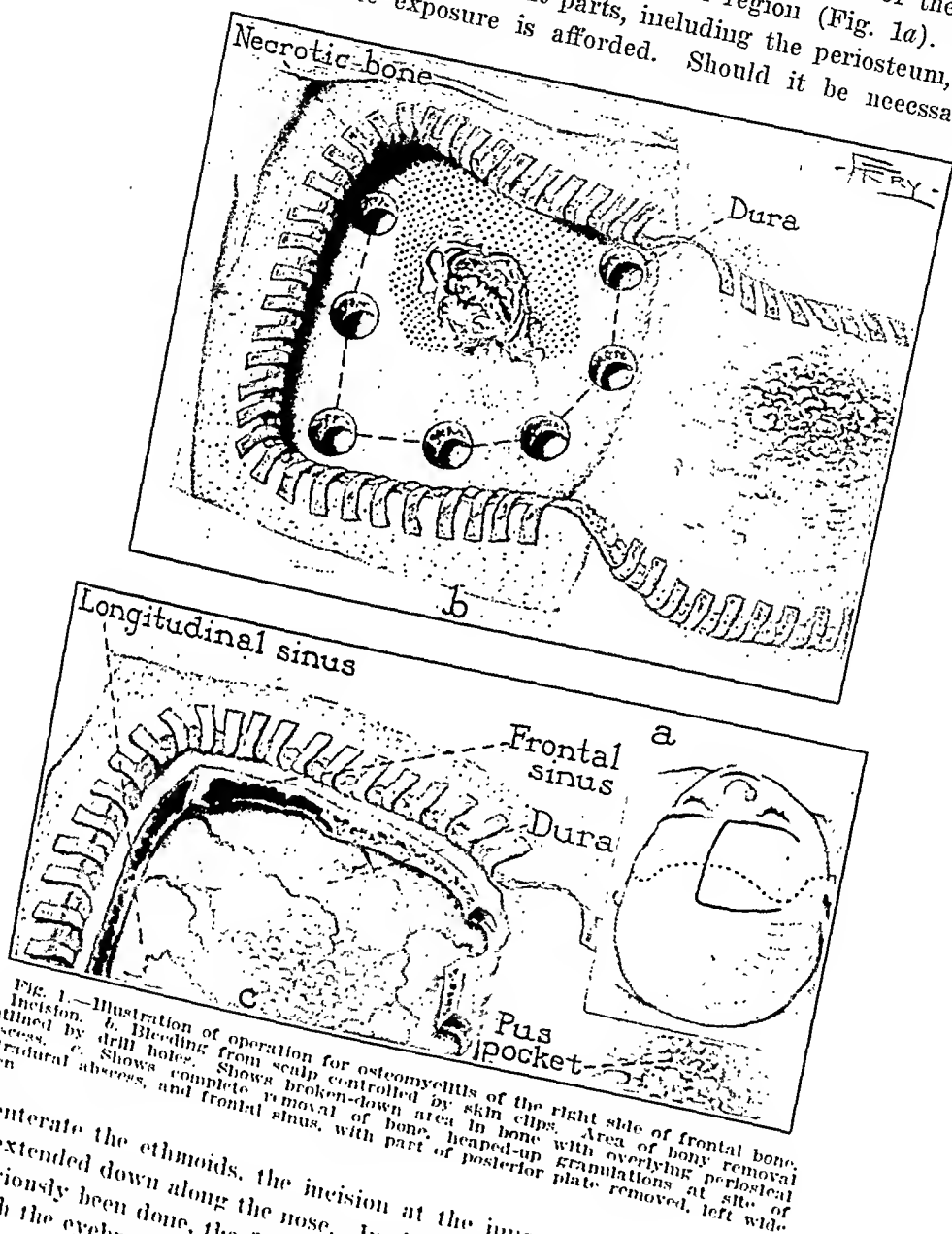
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yond the midline over the root of the nose; upward and backward for a distance of one inch or more beyond the edema of the scalp; downward and outward into the temporal region (Fig. 1a). When this flap, consisting of all soft parts, including the periosteum, is reflected, adequate exposure is afforded. Should it be necessary to



exenterate the ethmoids, the incision at the inner canthus can easily be extended down along the nose. In the event a Lynch operation has previously been done, the first line of incision follows the old scar beneath the eyebrow instead of above it, to avoid having two scars.

made in the skull to allow escape of pus. These patients are in poor condition at best, and will not withstand successfully massive, radical resection of the skull.

Ventriculograms.—Should the presence of a brain abscess be strongly suspected, but without marked localizing signs and symptoms, preliminary ventriculograms are indicated. Should an abscess exist in the frontal lobe, ventriculograms will definitely establish the location of the lesion. This method is preferable to an exploratory puncture through an infected dura after the bone has been removed, and it can be done with a reasonable degree of safety before the radical procedure. Ventriculograms are preferred to encephalograms. Localized meningitis might be spread in making the latter.

It is advisable to drain a brain abscess if it can be located at the time of resection of skull, rather than at a later date. The exposure is all one could desire for drainage of the abscess. Should an underlying abscess be present, and not drained at the time of the radical operation on the bone, there is danger of rupture into the ventricle or meninges during the interval of waiting. It is reasonable to assume that the underlying brain is edematous in all cases of osteomyelitis with an extradural pocket of pus, associated with headache and other symptoms of brain abscess. Thus, one may not recognize the presence of an abscess.

From the ventriculograms one could make the diagnosis, and localize it or prove its absence. The intracranial symptoms may be due only to edema or localized serous meningitis. A hazardous exploratory puncture through the infected dura would then be obviated. I probably lost two patients due to the fact that preliminary ventriculography was not carried out.

PRINCIPLE POINTS IN THE OPERATIVE PROCEDURE

Anesthesia.—I have found that the best anesthesia is a combination of avertin and regional. Avertin reduces blood pressure and lessens the tendency to bleed. In most suppurative conditions, local anesthesia is contraindicated. In this operation, however, as in brain abscess, it is very efficacious. Bleeding is lessened due to the admixture of suprarenin with the novocain. The anesthetic effect lasts for at least two hours. Should there be restlessness and moving of the head, a small amount of ether is advisable. A postnasal plug is used in all cases of osteomyelitis of the frontal bone.

Incisions.—When the disease is localized to one side of the frontal bone, the following incision is advised. Beginning at a point beyond the outer canthus, the incision is carried inward just above, and not through, the eyebrow to a point just above the inner canthus; for a short distance obliquely upward and inward, about one-half inch be-

continuous oozing which takes place from the dura, and during the obliteration of the frontal sinus. After removal of the mucous membrane extending into the opening of the nasofrontal duct, iodoform gauze is packed firmly into the remaining portion of the sinus and left. Bleeding in this region will then cease. By leaving the central necrotic portion of bone as the last to be removed, bleeding from the dura can thus be lessened.

Regardless of what one may do there is a certain loss of blood. We have routinely followed each operation with a blood transfusion.

Amount of Bone Removal.—All writers who advocate resection of the skull state that a sufficient amount should be extirpated to insure complete removal of the diseased bone. This has been especially emphasized by McKenzie, Bulson, Furstenberg, Adson, Wileusky, and Mosher. Furstenberg begins in the grossly infected and broken-down area and extends his bone removal as far as he considers it necessary.

I agree with Mosher who states: "The edema of the skin of the forehead is a rough guide to the extent of the bone and the periosteal infection. Further . . . if there is actual bone necrosis, the bone is infected without necrosis for 1 to 1½" beyond the necrotic area." To substantiate his opinion, he removed bone at varying distances from the actual necrotic portion, and sectioned them. He was able to see the changes in the bone from the diseased to the healthy bone structure. Furstenberg states: "Both outer and inner plates are removed, and the resection is carried well beyond the obvious limits of the disease. For reasons already described it often seems feasible to limit the resection of the cranial bones to a suture line."

When a trephine opening is made at a given position, should droplets of pus exude from the diploe, it is obvious that the drill must be set farther back in order to insure complete removal. The bone may be removed in one piece or piecemeal (Fig. 1c). I have done both. It seems to make little difference which method is used. The former is quicker and leaves a well-shaped portion of bone for reinsertion at a later date, should this be desired. At times I have found the dura quite adherent at certain areas, and have felt that removal in one piece would jeopardize the integrity of the dura. At all odds, the dura should not be unintentionally opened.

The frontal sinus, or both sinuses, if they are diseased, should be widely opened, and the ethmoids exenterated, if deemed advisable. I agree with Mosher that the full external limit of the frontal sinuses should be exposed and removed if necessary to allow complete obliteration of the sinus. It has likewise been observed that this is a "danger spot" and may be the source of recurrence. It has been noted also that a portion of the anterior plate forming the supraorbital ridge can

Should the disease involve both sides of the frontal bone, I prefer making a similar flap on the opposite side rather than the inverted T-shaped incision. Better exposure can be obtained, the upper or posterior margin of the bone defect will not be covered with scalp, and scarring will not be increased, for the reason that the upper limbs of the incisions are well within the hairline. If the disease is generalized, two large bilateral anterior scalp flaps are made simultaneously so that the anterior portion of the skull can be removed. The incisions are similar to that for an osteoplastic flap. Later, similar posterior flaps should be made with removal of the posterior part of the skull. This requires two or three stages.

Control of Bleeding.—In these cases, the scalp bleeds very vigorously, and it is imperative to control bleeding throughout. The procedure necessarily requires considerable time and some loss of blood, in any case, during removal of the bone. The initial loss of a small amount of blood does not affect the patient, but continuous loss weakens the patient to such an extent that the surgeon may have to discontinue the operation, or finish it in a hasty and inconclusive manner. Therefore, systematic control of bleeding is highly essential from the beginning of the operation.

When the incision is made, it is carried down at the particular point to the outer table of the skull for one inch or one and a half inches at a time. The scalp edges are reflected, and skin clips are applied to the cut edges on both sides of the incision and are closed snugly. This manner of controlling bleeding from the scalp is consistently carried out step by step until the complete incision is made (Fig. 1b). When the flap is reflected, major bleeding points from the under surface are touched with the coagulating electrode, and the scalp flap is wrapped in gauze. Some oozing will take place, especially from the limb of the incision over the supraorbital ridge. Angulated, self-retaining retractors inserted at this point will control the oozing. In removal of the bone, should retention of it as one piece not be desired, the upper or posterior portion of the area should be first attacked by removal of the entire thickness of the skull between drill holes in healthy bone (Fig. 1b). The full extent of bone extirpation should be decided upon and carried out at a given point, and the margin of the bone covered with iodoform gauze. Pressure by an assistant for a short time will control bleeding from the bone margin at a given point. Bone wax should not be used on the skull margins which are to remain, for the reason that it will act as a foreign body and may be a source of infection after the incision has healed.

Systematic removal of bone about the periphery should be continued and the bone edges covered with iodoform gauze in the manner described. By this method all bleeding will be controlled except the

Peroxide is invaluable in loosening the very adherent gauze from the dura and in allowing slow removal of gauze without tearing the dura. The iodoform gauze packing in the remnant of the frontal sinus is removed and renewed. Similar pieces of gauze are placed on the dura, the flap is returned to its position, and dressing applied. It is not necessary to resuture the flap at this time. It will not shrink after six days. By the tenth day, the edges of the bone which have been in apposition to gauze will have become covered with healthy granulations. Under avertin anesthesia the gauze between the flap and the dura (Fig. 5B) is removed, and the scalp flap is loosely sutured in position, gapping well between sutures. Into these gaps, small pieces of iodoform gauze are packed. After three days, the scalp flap will have become adherent to the dura. Sutures are removed, leaving the two scalp margins separated one-fourth to one-half inch. This assures adequate drainage for the cut margins of the bone and successfully mitigates against reinfection of the bone edges. The troughlike gapping incision is loosely filled with iodoform gauze strips which are renewed daily or every other day until the wound has completely healed (Figs. 6A and B). The lower inner angle of the flap is left open so that prolonged packing of the dimplelike remnant of the frontal sinus can be done. It is most important that the sinus be completely obliterated with firm granulation tissue, otherwise reinfection would most likely occur. Mosher also emphasizes this point.

Plastic Procedure.—It is advisable to wait for six months or probably a year before the plastic procedure is performed. During this time, should a small subcutaneous pus pocket develop about a bone fragment which has not been removed, it can be opened and drained without interfering with the final cosmetic result. Furthermore, latent infection will not be stirred up at the time of the plastic procedure. It is remarkable how little scarring there is in some cases, even without a plastic procedure. The scalp becomes softened during the interval of waiting, and after the sear has been excised, the scalp edges can be easily approximated without tension and danger of infection and sloughing. It will be observed that the vertical sear has been drawn over to or beyond the midline, although the incision was made one-half inch beyond. The cosmetic result is good. The only noticeable part of the sear is from the inner canthus of the eye to the hairline. This portion may be obscured by vertical wrinkles. The sear resulting from the other two limbs of the incision is concealed in the hairline and above the eyebrow.

The average stay in the hospital for the last three cases of osteomyelitis of the frontal bone was forty-four days.

The general principles given above are followed in cases of osteomyelitis involving other bones of the cranial vault. Should it appear

be retained, and thereby diminish the deformity. The posterior plate should be removed low. If this is done, the entire cavity will be more quickly and completely obliterated with granulation tissue.

Closure.—If an opening in the dura leading into a cortical or sub-cortical abscess is found, and complete removal of diseased bone has been accomplished, the dura should be opened. Otherwise, exploratory punctures through the infected dura are inadvisable. If an abscess is drained, the scalp flap is sutured on itself, as described in a previous paper,¹⁷ to permit proper dressing of the abscess. If none is found, all loose pieces of bone are removed from the surface lest they act as a source of reinfection. The strips of iodoform gauze which were placed along the bone margin and in the remnant of the frontal sinus are left in position. The dura and the operative field are washed off with azochloramid solution, pieces of gauze flats wet in the same solution are laid on the dura within the bone defect to the level of the outer table of the skull, with a rubber instillation tube placed between the pieces of gauze. The scalp flap is then returned to its position overlying the gauze packings, and it is loosely sutured with bridge sutures to the scalp margin about the defect, leaving the margins about one-fourth of an inch apart. These sutures prevent shrinkage and contraction of the flap. The skin clips which were placed on the scalp margins to control bleeding are left in position. Otherwise, bleeding from the scalp edges would be marked. The clips are not removed until the fourth day, at which time practically no bleeding occurs. I have never swabbed off the dura and bone edges with tincture of iodine as advocated by Adson, but I see no objection to it. No drainage tubes are necessary in that the area is wide open.

Both eyes and ears are well covered with vaseline gauze. A copious gauze dressing wet in azochloramid solution is applied and loosely fixed with a wet bandage and strips of adhesive, including the lower jaw, to prevent removal or slipping of the dressing. If a tight dressing is applied, compression of the brain through the bone defect will occur.

Postoperative Treatment.—Fluids are given very freely. If the patient becomes irritable due to increasing intracranial pressure, this can be lessened by administration of hypertonic sugar solution, copious bowel movements, and lumbar puncture, if necessary.

The first dressing is done on the second day, and all the dressing down to the flap is removed and renewed. It is well to protect the scalp with a mixture of zinc oxide and olive oil to prevent irritation by the solution. Instillation of azochloramid is done through the tube every two hours. This keeps the wound clean. No actual pus has been observed.

On the sixth day, under avertin anesthesia, the original gauze packings beneath the flap and against the dura are removed (Fig. 5A).

most part, there is but little tendency for the defect to decrease in size. This statement is made after several years of personal observation of these defects. The facts substantiate to a degree the assumption of osteogenetic power or function of the dura made by Furstenberg.

In several recent cases of osteomyelitis in which the skull was generously resected, I have observed that regeneration is taking place at a surprisingly rapid rate (Fig. 2). In one case, it is complete. This has occurred without any outside aid other than good food and hygiene. Furstenberg emphasizes the unquestionable value of infra-red light, but this light has not been used.



Fig. 2.—X-ray film showing amount of bone regeneration twenty months after radical resection of right half of frontal bone.

Naffziger,²⁹ in a recent article, advocated removal and preservation of the bone in an osteoplastic flap in certain cases of tumor. He replaced the bone either with or without boiling, following removal of the tumor. Several years ago, Dorothy Klenke, an associate on our neurosurgical service at Bellevue Hospital, removed the bone from a flap, in the belief that the underlying tumor was irremovable. The bone was sent to the laboratory. Several days later a second-stage operation was performed, and a benign tumor was removed. She sent to the laboratory, retrieved the bony portion of the flap, had it boiled, and replaced it in the defect. The wound healed by first intention.

that I have gone too much into details, I have done this for two purposes. First, with the hope that my experience may be of some benefit to others who have been combating this disease, and second, with the intention of "spreading the gospel" which has been so ably propounded by other writers, especially Furstenberg and Mosher.

REGENERATION OF BONE

McKenzie, in 1927, noted that "the defect in the frontal bone will subsequently be made good by new bone formation and this repair takes place rapidly." He did not state the length of time required. There are numerous other brief references to bone repair, but the first full discussion of the subject that I am able to find is by Furstenberg in 1931. He stated that the dura under favorable conditions is an exceedingly active regenerative tissue, in addition to the periosteum. His eight cases which survived were cured. The defects in the skull, which ranged in size from small defects to one including the cranial vault, were all completely closed "at the end of a period exceeding two years." This is sufficient evidence to disprove the arguments of those who have the "defect bugaboo."

Regarding the manner in which regeneration takes place, he states: "The regenerated bone has for its origin a connective tissue groundwork. The fragments and shreds of traumatized periosteum remaining within the wound become thickened and congested, and assume the appearance of granulation tissue. The latter serves as a young connective tissue base of an embryonic character in which ossification may follow. There is a rapid multiplication of connective tissue elements with a differentiation of some of the cells into osteoblasts. Thus there is formed an interlacing framework of trabeculae which is at first uncalcified, and is spoken of as osteoid tissue. The latter soon is infiltrated with calcium salts and there are formed numerous trabeculae or spicules of bone, completing the process of ossification."

After the operations done by him and the others of us who advocate wide skull resection, the periosteum and dura, which are the two main bone-forming tissues, are approximated. Both dura and periosteum are preserved. Regeneration should and does take place.

At the time of débridement of a compound fracture of the skull with loss of brain substance, both the dura and the periosteum may have been sacrificed to a considerable degree. In the instances where both dura and periosteum were removed, the degree of regeneration, if any, was slight. Cranioplasty¹⁸ was necessary for closure of these defects. Likewise, in a smaller number of cases of brain abscess in which the dura is deliberately removed, yet the *periosteum* is preserved for the

most part, there is but little tendency for the defect to decrease in size. This statement is made after several years of personal observation of these defects. The facts substantiate to a degree the assumption of osteogenetic power or function of the dura made by Furstenberg.

In several recent cases of osteomyelitis in which the skull was generously resected, I have observed that regeneration is taking place at a surprisingly rapid rate (Fig. 2). In one case, it is complete. This has occurred without any outside aid other than good food and hygiene. Furstenberg emphasizes the unquestionable value of infra-red light, but this light has not been used.



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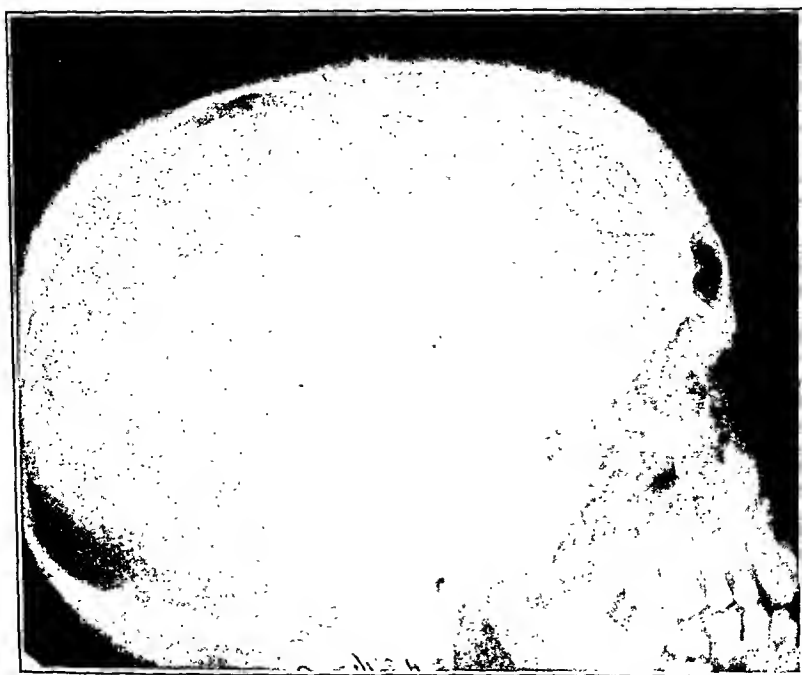
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Naffziger stated that "in selected cases of osteomyelitis, particularly of the postoperative type herein mentioned, such procedures have given a new direction to the surgical problem." The case which he reported was one in which the wound became infected following an osteoplastic flap for the removal of a pituitary adenoma. He did not make reference to a case of true osteomyelitis such as is considered in this paper.



Fig. 3.—Patient S. P. A. A. P. x-ray film showing extensive osteomyelitis of frontal bone September 3, 1935. B. Lateral view of x-ray film, C. Photograph of patient on same date.

On July 2, 1935, before becoming acquainted with the work of Naffziger, I removed a bloc of infected bone three inches by four inches from the left temporoparietooccipital region in a case of metastatic osteomyelitis secondary to a lung abscess. I expected to reinsert the piece of bone after twelve months had elapsed. Unfortunately the disease extended back into the occipital bone and across the midline into the opposite parietal bone, necessitating several subsequent resec-



B.



C.

tions by my associate, Wilfrid D. Wingebach. Meanwhile, regeneration of bone in the defect from which the first large piece of bone was removed has taken place to such an extent that implantation of the bone will probably not be necessary.

This method, which Naffziger proposed for the closure of a large defect, might be utilized in cases of massive resection of the skull for generalized or extensive metastatic osteomyelitis. Since regeneration of the skull is so complete, according to Furstenberg, it is questionable if any attempt at closure should be done.

I shall give a fairly complete report of one typical case with illustrations of the operation, and prints of x-ray films showing the progress of a given case. The recovered cases show great similarity. Detailed reports of all the cases will be made in another paper.

Infection following swimming. Suppurative ethmoiditis and sinusitis. Ethmoidal perforation. Orbital abscess drainage. Osteomyelitis of frontal bone. Massive skull resection with obliteration of sinus. Recovery.

S. P., fifteen-year-old schoolboy, was admitted to Manhattan Eye, Ear, and Throat Hospital to the service of Dr. David Jones on August 5, 1935, and was attended by Dr. Knopf. (Hospital No. 284396.)

History and physical examination showed that the patient went swimming one week before admission, and two days later developed pain, redness, and swelling over both eyes. The condition became steadily worse. On August 4, a swelling appeared behind the angle of the lower jaw on the right. On admission, there was marked redness, swelling, and tenderness of the upper and lower lids of both eyes with chemosis, much more marked on the right. There was enophthalmos with proptosis on right, but none on left. The right eye was fixed, while the left moved somewhat and there was photophobia in both. Ear examination was negative. Congestion of middle turbinates with creamy yellow pus from right and none from left was noted. Swelling the size of hen egg showed behind angle of right jaw. There was no induration or suppuration, and glands were palpable. The general examination was negative, and the patient was mentally alert.

Examination gave an impression of acute frontal ethmoiditis, right, with possible early cavernous sinus thrombosis. Temperature, 103.6°; pulse, 100; respirations, 24. W.B.C., 21,500; polymorphonuclears, 82; lymphocytes, 18. Blood culture, negative.

X-ray examination showed involvement of all sinuses, most marked of ethmoids, more on the right than on the left. Frontal sinuses were of average size. The ophthalmologic report showed vision O.D. 20/20; O.S. 20/20. There was marked boggy edema of the right upper lid and the region above the right orbit; maximum tenderness at the upper outer segment of rim of orbit; marked chemosis of conjunctivae with moderate proptosis of globe, and very little mobility of globe. The cornea was clear, the pupil moderately dilated, and the iris and lens negative. Satisfactory examination of fundus did not reveal any gross pathology. Diagnosis: Orbital abscess.

On the same day an incision was made along right supraorbital ridge; the periosteum was opened with release of moderate amount of pus. A counter parallel incision was made halfway down the upper lid. Guttu-percha drains were placed, and the wound was loosely sutured.

Temperature ranged between 101° and 102° for the next nine days. August 14, an external left ethmoidectomy and Lynch operation was performed by Knopf and

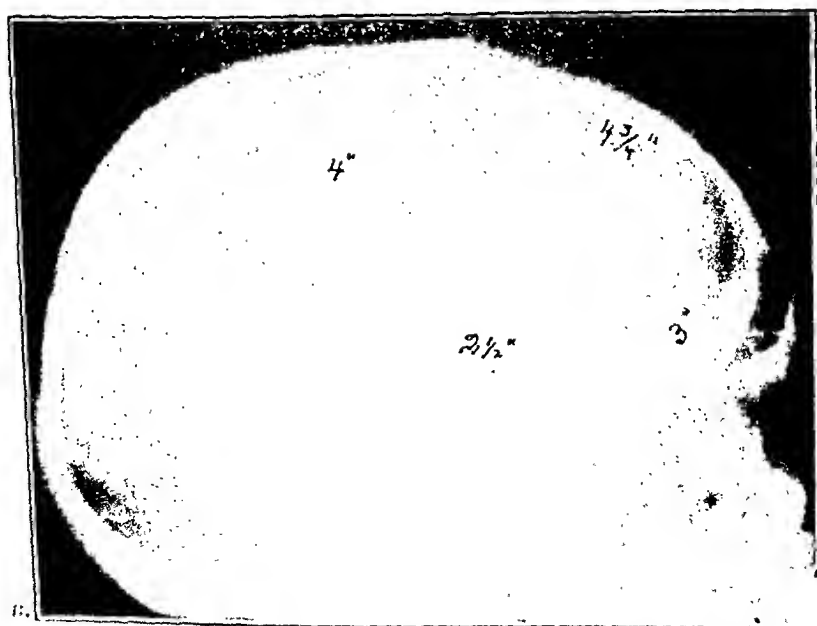
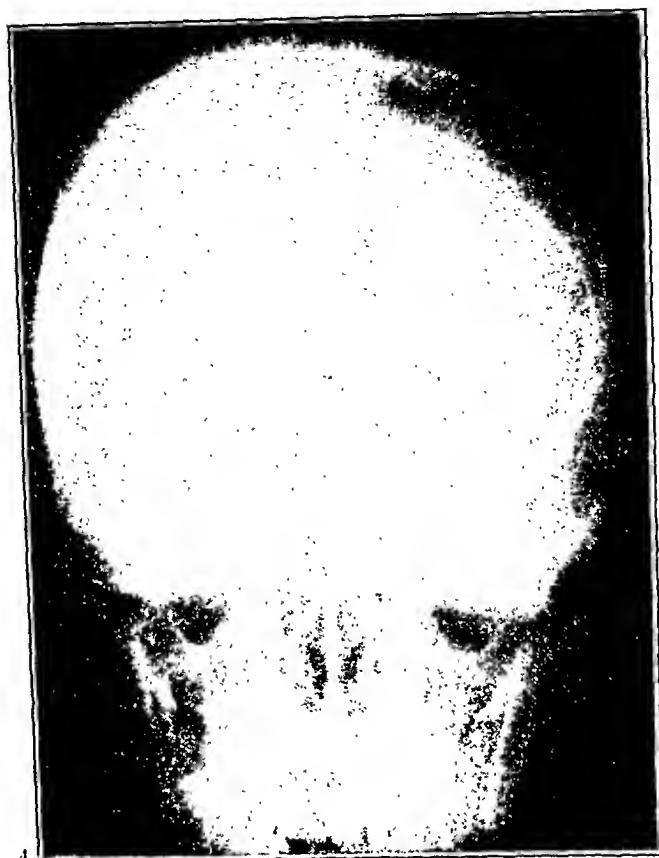


FIG. 4.—Patient S. P. 1. A. P. X-ray film showing skull defect extending beyond the midline line. No evidence of extension of infection. Two months postoperative. B. Lateral view of X-ray film showing size of skull defect.

Dura on the right side, with anterior ethmoid perforation into orbit. Ethmoids were found to be soft and mushy. The floor of the frontal was removed; polypoid lining. Iodoform gauze pack from frontal sinus into nostril. Tube drain was placed from nose out to the angle of the wound. Rubber dam drain outer angle. Temperature declined and ran between normal and 101°. Patient complained of but little pain.

August 29, evidence of edema and fluctuation over the right frontal area was noted. August 30, x-ray films showed extensive osteomyelitis involving almost the entire right half of the frontal bone extending well into the midline and almost to the coronal suture (Figs. 3A and B). The frontal sinus was cloudy, as at previous examination made August 5, and no films were made in the interim.



A.

Fig. 5.—Patient S. P. A. Appearance of wound on sixth postoperative day after removal of gauze beneath flap overlying dura. Bone edges becoming covered with granulation. Dura covered with healthy red granulations. Bleeds freely. Skin clips removed from scalp on fourth day. B. Appearance of wound with gauze beneath flap before its removal on tenth postoperative day.

September 1, W.B.C. 13,850, polymorphonuclears 72. Transfusion of 300 c.c. blood. September 3, x-ray films showed no appreciable change in involved area since August 30.

I saw the patient on September 3. His appearance was as shown in Fig. 3C. Temperature was 100.4°, pulse, 98. Radical skull resection for osteomyelitis was advised. This was done on the following day, September 4, under avertin and ether anesthesia.

There was marked edema and swelling of right frontal region of both eyelids of right eye. Three discharging sinuses, each presenting a rubber tube, were present in incisions made for drainage of orbital abscess and abscess of the scalp. "Potts'

puffy tumor" had previously existed. The outer table of skull presented typical moth-eaten appearance of extensive osteomyelitis with numerous sequestra. That portion of the bone over and adjacent to right frontal sinus was reddish in color, while that above the broken-down area was whitish, or yellowish white. There was an extradural abscess which did not extend far beyond the 2 by 2½ inch broken-down area. The dura was markedly thickened, with heaped-up granulation tissue here and there adherent to pieces of necrotic bone. There was no sinus leading down through the dura. The frontal sinus contained thick yellow pus, a culture of which showed *Staphylococcus aureus*. The operation was carried out as described (Figs. 1 a, b, and c). (These drawings were made from another patient.) Resection of skull



B.

was extensive, and it was not removed in one piece. The size of the defect is shown in Figs. 4A and B. Afterward the patient was given a transfusion of 450 c.c. of blood by Eggston.

Azochloramid solution was instilled into the dressing every two hours. Skin clips were removed from scalp margins on the fourth day. Temperature was normal on the sixth day, and gauze packing was removed from beneath the scalp flap under avertin anesthesia. Condition of the operative area was good (Fig. 5A). The flap was replaced, but not sutured.

Second removal of gauze beneath the flap (Fig. 5B) was done on the tenth day under avertin anesthesia. Temperature was normal. The flap was loosely sutured in position, gapping at intervals. Four days later, sutures were removed, and the troughlike area about the flap remained until healed by granulation (Figs. 6A and B). Bone edges were well covered. Temperature remained normal throughout

remainder of the patient's stay in the hospital. The patient could have been discharged to outpatient department a month following operation, but was retained until the wound was completely healed. He was discharged completely cured on the sixty-second postoperative day. He had gained eighteen pounds in weight while in hospital. Radiographic films (Figs. 4A and B) were made on the day of discharge and showed no evidence of recurrence of the disease. He has remained well since.

A plastic procedure for cosmetic reasons will be done at an early date, although the appearance of the scar at the present time is not very disfiguring. Bone regeneration has taken place to a marked degree.

This was indeed a satisfactory result. It is believed that similar results should be obtained in a majority of cases of osteomyelitis of the frontal bones and of the other bones of the cranial vault, provided the only complications are extradural and subperiosteal abscesses.

RESULTS AND COMMENTS

A fairly large number of cases of local osteomyelitis following gunshot wound of the skull observed in Germany and in this country during the late war, infected compound fractures, electrical burns, severe damage or avulsion of the scalp, etc., are not included in this series. These conditions do not belong properly in the category of the cases under consideration. I performed a cranioplasty on two cured cases of John McCoy, to one of which he made reference in his discussion of a paper by Bulson in 1925. These cases are excluded.

The series includes seventeen patients, twelve males and five females. The average age was thirty years. Eight were twenty-two years old or less. The youngest was one year, and the oldest fifty-six. Six were over forty years of age. *Staphylococcus aureus* was the predominating organism. The source of infection was the frontal sinuses and ethmoids in thirteen cases. Three were metastatic; one secondary to a lung abscess; one to a blood stream infection following an infected wound of the hand; and one to osteomyelitis of tibia and femur.

Only two patients had not been operated upon previously for some condition, and in these two the frontal sinuses had been probed. Several cases had undergone multiple operations. Ten recovered, seven died.

Of the seven who died, four were hopeless cases from the time they were first seen by the author. One had generalized osteomyelitis involving the entire cranium, both mastoid processes, right malar bone, and left mandibular articulation. How far it extended into the base was not known. Radical operation could not be done. Autopsy was not performed.

One patient had generalized osteomyelitis of the skull which apparently was being controlled when metastasis to the cervical spine occurred, followed by meningitis. Another had pansinusitis, followed by rapid generalized osteomyelitis of the skull without breaking down of either table, with a large extradural "lake" of pus, and meningitis.

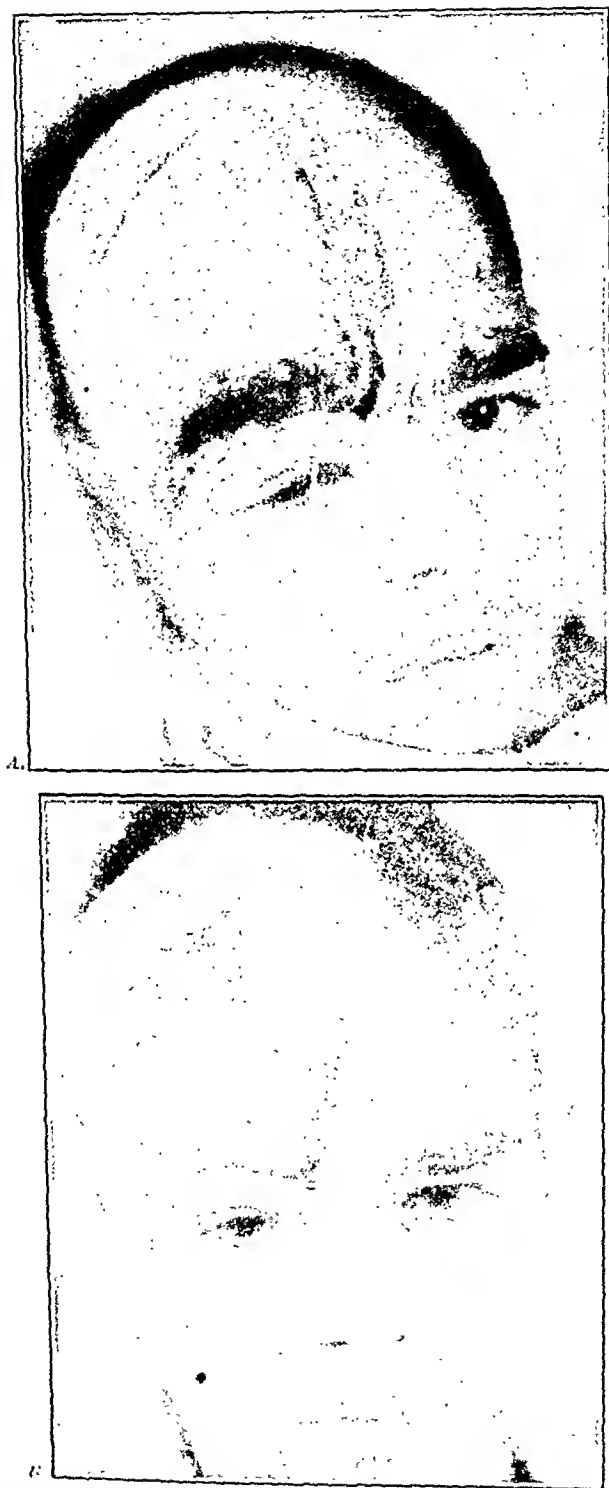
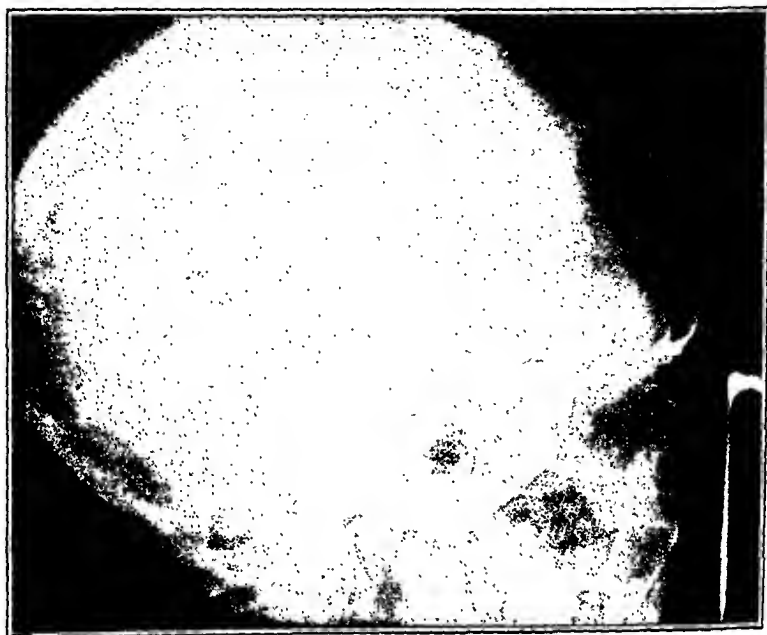
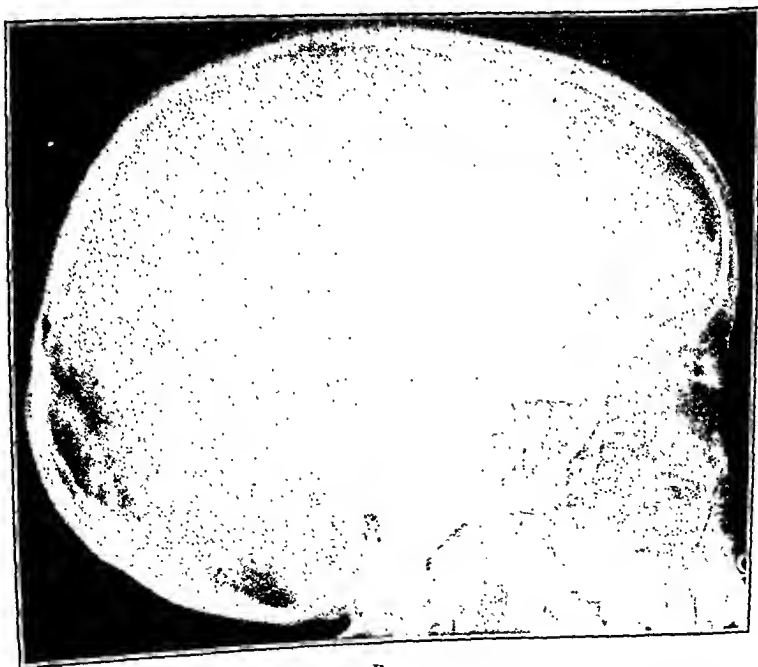


Fig. 6.—Patient S. P. 1. Appearance of wound on twenty-fifth postoperative day. Linc. edges well covered with healthy granulations. B. Appearance of wound on fortieth postoperative day. It is practically healed. Only a small dimple remains at median inferior angle. Frontal sinus obliterated.



A.



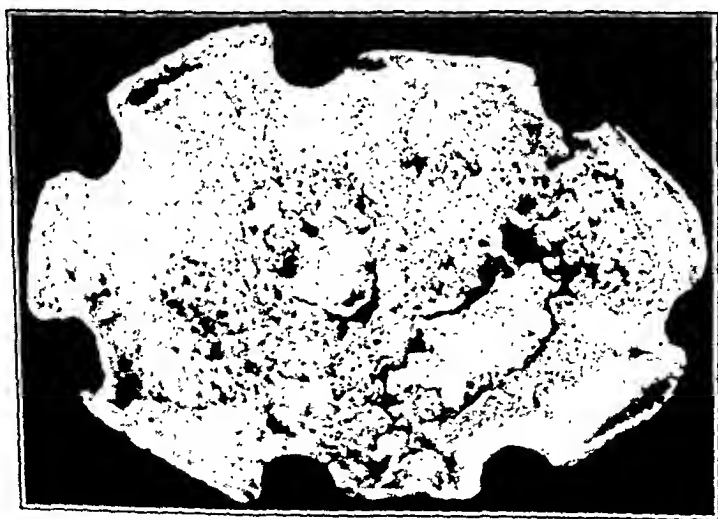
B.

FIG. 7.—X-ray films showing size of skull defects following radical resection. *A.* C. B., seventy-seventh postoperative day, August 11, 1933. *B.* D. B., fortyeth postoperative day, November 6, 1935. *C.* J. C., fifteenth postoperative day, July 17, 1935. *D.* Bloc of skull, 3 by 4 inches, removed from skull of patient, J. C.

The fourth patient had a brain abscess which had already ruptured into the meninges, and suppurative leptomeningitis had developed.

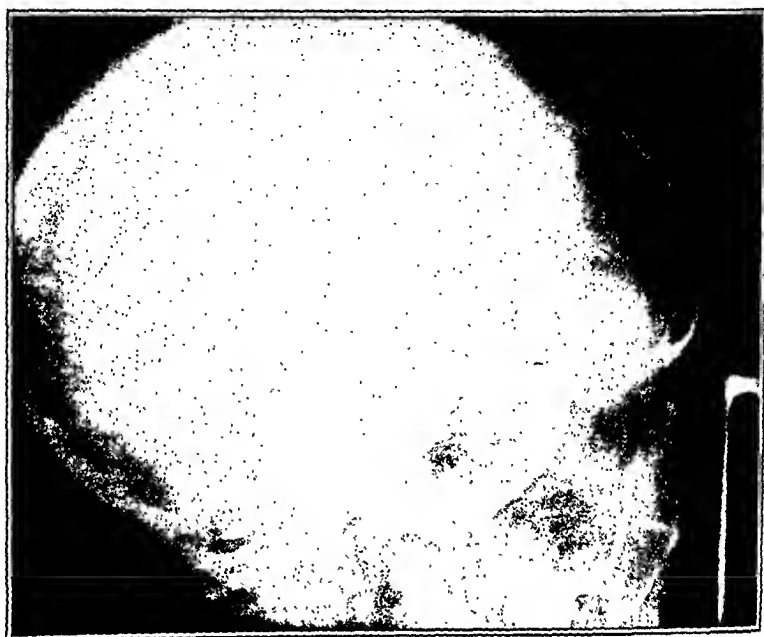


C.

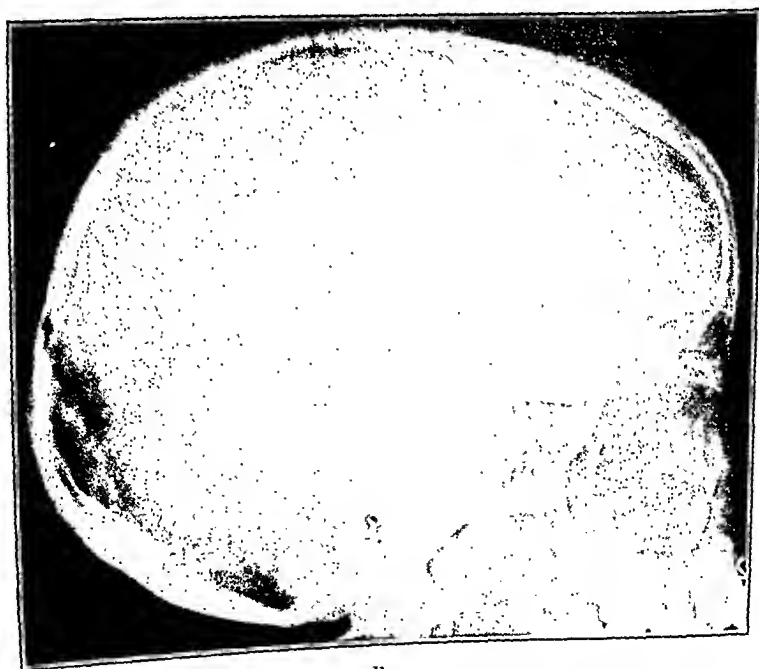


D.

Of the other three who died, one had marked involvement of the right side of the skull with multiple brain abscesses. Another was a woman of fifty-six years of age, in whom a frontal lobe abscess was



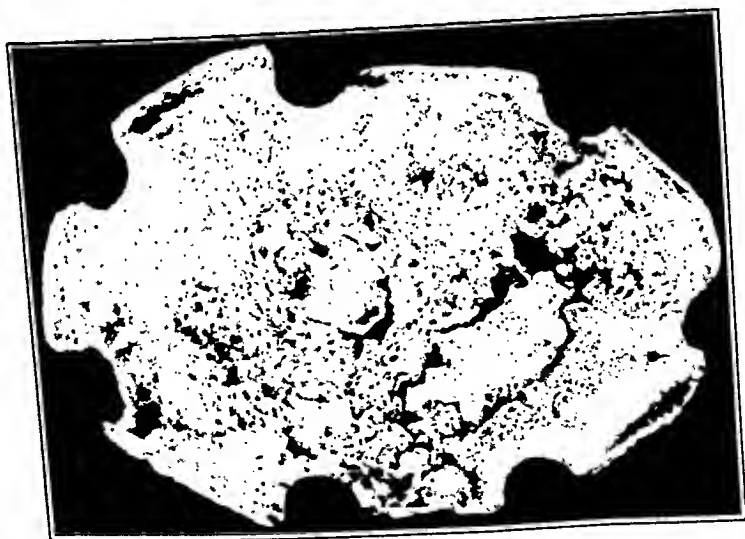
A.



B.

FIG. 7.—X-ray films showing size of skull defects following radical resection. A. C. B., seventy-seventh postoperative day, August 11, 1933. B. D. B., fortieth postoperative day, November 6, 1935. C. J. C., fifteenth postoperative day, July 17, 1935. D. Bloc of skull, 3 by 4 inches, removed from skull of patient, J. C.

The fourth patient had a brain abscess which had already ruptured into the meninges, and suppurative leptomeningitis had developed.

*C.**D.*

Of the other three who died, one had marked involvement of the right side of the skull with multiple brain abscesses. Another was a woman of fifty-six years of age, in whom a frontal lobe abscess was

suspected, and in whom a large suppurating mass in the right upper abdominal quadrant developed and was aspirated. She was too ill for drainage of either area.

The seventh case probably should have recovered. An underlying brain abscess was suspected, but aspiration through infected dura was deemed inadvisable. Ventriculograms were not made. While I was attending a surgical meeting, the patient, who had been doing reasonably well, became comatose with sudden high elevation of temperature, and died. His death was most likely due to spontaneous rupture of an abscess into the ventricle. Autopsy was not performed. This is the only one of the seven cases on whom the desired radical resection of the skull was done. It could not be done in the other six.

Of the ten cases who recovered, the disease in two of metastatic origin affected the parietal bone of one side. In one, a single operation was performed. In another, multiple resections were done. The latter lost over half of his cranium. In the third case of metastatic origin, the frontal bone was involved. A single operation was performed. In the remaining seven, the disease involved only the frontal bone, five extensively. In two, the incision advocated by Mosher was used. One patient was operated on by Richard Atkins, and I operated upon her for a brain abscess. The second operation was performed by Edgar M. Pope under my direction. The other five patients were operated upon as desired, according to the method described. Only one of the ten patients was operated upon more than once for osteomyelitis. The longest time since operation is over three years, and the shortest three and one-half months. The best results have been obtained in the last few years by the initial complete resection of diseased bone.

SUMMARY

1. Treatment of osteomyelitis limited to the bones of the *cranial vault* is considered. Treatment of disease involving the accessory nasal sinuses per se, mastoid, petrus, maxilla, mandible, and basillar portion of the skull is not within the scope of this paper.

2. Earlier diagnosis can be made by more frequent x-ray examinations after the disease is suspected. The softened and partially decalcified region of the skull can be recognized several days before the moth-eaten appearance accompanying actual necrosis is observed. Exploratory drill hole may be done and diagnosis established. Earlier operation can then be instituted.

3. Preliminary ventriculograms—not encephalograms—are advised for the purpose of diagnosing and localizing a brain abscess when its existence is strongly suspected as a complication, provided the general condition permits. A brain abscess can be opened at the time of

operation for osteomyelitis. Dangerous transdural punctures, which might produce an abscess, were it not already present, and rupture of the abscess into the ventricle, would be prevented.

4. Special points in the operative procedure and postoperative course have been emphasized.

5. Closure of the skull defect following radical resection by regeneration of bone occurs, completely in younger people in the absence of prolonged infection and reinfection. Bone regeneration renders implantation and transplantation unnecessary.

6. "Conservative treatment" can be advised only in the most serious cases complicated by sepsis, meningitis, etc. Most of these cases will die in any event. Radical resection of all diseased bone is advocated and urged whenever possible. Halfway measures are condemned. Cure can and should be expected in the majority of cases with no complications other than extradural and subperiosteal abscesses. In other words, if the operation which was advised by McKenzie is properly done, most cases should live.

7. Results. Seventeen cases were operated upon, three of metastatic origin. Ten recovered, seven died. Six of the latter had but little chance of surviving when first seen by the author. One probably died from rupture of a suspected but undiagnosed brain abscess.

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PHYSIOLOGIC EFFECTS PRODUCED BY ABLATION OF THE
AUTONOMIC CENTRAL INFLUENCE.
VARIOUS FORMS OF SYMPATHECTOMY IN THE TREATMENT
OF DISEASES*

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INTERRUPTION of sympathetic fiber tracts in the treatment of various diseases reveals interesting clinical and physiologic findings. These suggest that the fault in the autonomic mechanism is located in the centers of the cerebrospinal system rather than in the peripheral system. The fact that the smooth muscles of the blood vessels and visceral organs, the cardiac muscles, pilomotor muscles, and the sweat, sebaceous, salivary, and other secretory and excretory glands are innervated by fibers from the autonomic nervous system indicates that pathologic states may arise from excessive or decreased stimuli carried over this nervous system. The rationale of surgical treatment of these various diseases is to regulate the number of stimuli by sectioning sympathetic pathways, rami and trunks, and to remove sympathetic ganglions in order to decrease the number of central impulses carried to the organ or tissue involved.

ANATOMY

The following brief review of the anatomy and fundamental physiology involved is presented with the hope that it may aid in a better understanding of the reactions that follow various types of sympathectomy:

According to White,⁵⁵ "the autonomic system, in both its cranial and thoracolumbar divisions, is developed from migrating cells which leave the brain stem and spinal cord in the early stages of embryonic development. These cells continue to divide by mitosis and thus form the peripheral visceral plexuses. Consequently, there is no fundamental difference between the autonomic and the cerebrospinal neurones."

Gaskell²¹ and Langley⁴⁰ classified the autonomic nervous system into two main anatomic and functional divisions: the *sympathetic*, or thoracolumbar outflow, and the *parasympathetic* or craniosacral division. The *cerebral* representation of the sympathetic outflow is presumably located in the paraventricular nuclei of the third ventricle of the hypothalamus, just posterior to the stalk of the pituitary body.

The investigations of Beattie, Brow, and Long (1930)¹¹ have shown the connection between the paraventricular nuclei and the lateral horn

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cells in the thoracic region of the spinal cord. These fibers, in traversing the cord from the medulla, follow rather closely the pyramidal system. White rami communicantes composing the thoracolumbar outflow originate in cell bodies located in the lateral columns of the anterior horns, and the fibers leave the cord by the ventral roots of the spinal nerves from the first thoracic to the second lumbar segments. These fibers invariably make synaptic connections with sympathetic neurones, which, as postganglionic rami, communicate with the visceral organs or the structures of respective somatic segments. According to Gagel,³⁰ anatomic studies show that autonomic control from these higher areas is transmitted to the peripheral plexuses through a series of nuclei in the medulla which lie close to the midline in the floor of the fourth ventricle. Another important reflex center in the medulla lies beneath the calamus scriptorius at some distance from the midline. These reflex centers appear to act as regulatory mechanisms, since the cardiac, respiratory, and vasomotor centers are closely associated with the motor nucleus of the vagus nerve.

The *parasympathetic* cerebral representation is presumably located in the hypothalamus, anterior to the sympathetic centers, in the supraoptic, tuber cinereum, and mammillary nuclei. The *cranial fibers* of the parasympathetic group leave the brain by way of the third, seventh, ninth, and tenth cranial nerves. The vagus is by far the most important of the involuntary nerves; however, it should be borne in mind that the vagus nerve is composed of involuntary and voluntary fibers. The *sacral parasympathetic* outflow leaves the spinal cord with the second, third, and fourth sacral nerves. After the mixed nerves have passed through the sacral foramina, these pelvic nerves (*nervi erigentes*) do not continue with the white rami to the sacral sympathetic ganglions, but run directly into the hypogastric ganglion and thence to the walls of the pelvic viscera. Their postganglionic neurones lie in the intrinsic plexuses of the genitalia, bladder, and rectum.

Papez and Aronson (1934)⁴⁶ have recently summarized the anatomic and physiologic data concerning the nuclei in the hypothalamic areas which have been shown to coordinate visceral activity and, to a large extent, to regulate human emotions. Fulton and his colleagues,²⁹ in their investigations, have found a certain degree of vasomotor and intestinal localization in the cerebral cortex, area 6 of Brodman. As expressed by Clark (1932),¹⁸ "the hypothalamus is the recipient of those vague and indefinable impressions which arise in association with all sorts of visceral activities and metabolic processes. Through its nervous connexions, and through the direct liaison which it establishes with the endocrine regulatory system via the pituitary, it mediates the integration of the visceral impulses and plays an essential part in the control of the internal milieu of the organism."

For a detailed review of the anatomic relationship of the autonomic system, I am much indebted to Ranson³² and Kuntz,³⁹ since I have frequently referred to Ranson's, "Anatomy of the Nervous System," 1928, which contains a very thorough neurohistologic review, and to Kuntz's, "Autonomic Nervous System," 1929, which presents a correlation of anatomic, physiologic, and pathologic facts. White's³⁸ "The Autonomic Nervous System" has proved of inestimable value as a reference, since it contains, in condensed form, data pertaining to the anatomy and physiology and to the surgical treatment of diseases arising from dysfunctions of the autonomic nervous system.

PHYSIOLOGY

The character of this paper does not permit full discussion of all physiologic reactions arising from stimuli carried over the autonomic nervous system. I shall, therefore, quote a summary from White's book, but before doing so, much credit should be extended to Professor Cannon and his collaborators who have extended the investigations of Claude Bernard,¹² Gaskell,³¹ and Langley,⁴⁰ who in turn are chiefly responsible for our present understanding of the physiology of the sympathetic nervous system:

"One of his (Cannon's) greatest contributions to this subject has been his observations on animals which have been totally deprived of sympathetic activity by removing the paravertebral ganglia from the neck to the lower lumbar regions (Cannon et al., 1929).¹⁷ These animals have lived in the sheltered conditions of the laboratory in good health for years. The animals become very sensitive to cold, as they have lost the ability to conserve heat. Erection of the hairs is permanently lost, but the peripheral arteries recover a degree of local vasomotor tone. Ability to perform muscular work and to resist fatigue is greatly reduced. These animals show no tendency toward vagotonia, as digestion is unchanged, the heart rate is only slightly slowed, and the blood pressure remains little altered. The basal metabolic rate is reduced about ten per cent. The cat becomes pregnant and reproduces in a normal manner, but is unable to nurse her young (Cannon and Bright, 1931).¹⁸ There are no noticeable growth changes in kittens which have had a total sympathectomy performed on one side. This shows that the sympathetic nervous system is relatively unimportant in a protected constant environment, but emphasizes its essential character in the conditions of stress and strain which are met in normal existence.

"In summing up the rôle of the *thoracolumbar* division of the involuntary nervous system, we should think of it as an emergency protective mechanism, which may not be functioning all the time, but which is always ready to go into action to combat any variety of adverse circumstance. Some of the most common conditions which arouse its activity are pain, extremes of temperature, asphyxia, haemorrhage, infection, dehydration, and hypoglycemia. Furthermore, any form of intense emotion or psychic trauma may stimulate a generalized sympathoadrenal discharge...

"Since the functions of the sympathetic nerves are catabolic and give rise to an extraordinary liberation of body energy, they are of a spendthrift character. Of equal importance to the body are the anabolic functions of the craniosacral (*parasympathetic*) division, which come into play during the periods of rest and reimpregnation and are of a conservative character. In summing up their activity I shall

cells in the thoracic region of the spinal cord. These fibers, in traversing the cord from the medulla, follow rather closely the pyramidal system. White rami communicantes composing the thoracolumbar outflow originate in cell bodies located in the lateral columns of the anterior horns, and the fibers leave the cord by the ventral roots of the spinal nerves from the first thoracic to the second lumbar segments. These fibers invariably make synaptic connections with sympathetic neurones, which, as postganglionic rami, communicate with the visceral organs or the structures of respective somatic segments. According to Gagel,³⁰ anatomic studies show that autonomic control from these higher areas is transmitted to the peripheral plexuses through a series of nuclei in the medulla which lie close to the midline in the floor of the fourth ventricle. Another important reflex center in the medulla lies beneath the calamus scriptorius at some distance from the midline. These reflex centers appear to act as regulatory mechanisms, since the cardiac, respiratory, and vasomotor centers are closely associated with the motor nucleus of the vagus nerve.

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"In 1876 Eulenburg and Landois²⁸ observed a rise in skin temperature of the contralateral extremities on ablation and a fall on stimulation of the motor-sensory area. These experiments have recently been repeated and corroborated by Pinkston, Bard and Rioch (1934).⁵⁰ Gowers and Bechterew have cited cases of hemiplegia and traumatic lesions near the 'central gyrus' in man with increased temperature of the contralateral half of the body. An interesting case showing unilateral vasomotor disturbance has recently been reported by Kennard, Viets, and Fulton (1934).³⁷ In this patient a tumour of the right premotor cortex caused redness, heat, and sweating over the entire left side of the body. . . .

"In a case of diencephalic tumour, reported by Penfield (1929),⁴⁸ extraordinary outbursts of autonomic activity appeared in repeated attacks. These manifestations consisted of cutaneous vasodilatation, salivation, sweating, and pilomotor activity. Tears flowed from both eyes, the pupils dilated, and in severe attacks the eyeballs protruded. The heart-beat became strong and rapid, while the respiration was slowed. Following an attack the woman became constipated and experienced difficulty in emptying her bladder. She finally died after a prolonged series of attacks. Post mortem examination revealed a cholesteatoma of the choroid plexus which protruded into the foramina of Monroe, causing an internal hydrocephalus. This tumour lay close to the region delimited by Bard.

"After working on the same subject from another angle, Cushing (1931 A and B)^{23, 24} has reported a series of interesting observations on the effects of pituitrin and pilocarpine injected into the cerebral ventricles. As is already well known, the hormone from the posterior half of the gland when injected intravenously causes vasoconstriction and stimulation of the muscle in the lower bowel. When introduced into the ventricle, on the contrary, Cushing found it to cause flushing, sweating, salivation, vomiting, and a pronounced fall in body temperature—a generalized parasympathetic response. Pilocarpine introduced into the ventricle gave a very similar response. The effect of both drugs was abolished by atropine, a further indication that the phenomenon was due to a parasympathetic discharge. In cases where the autonomic centers in the diencephalon were infiltrated by tumours, this reaction failed to take place. He observed that the effect produced on the parasympathetic system appeared to be as diffuse in its character as the response of the sympathetic to adrenaline. He believes that the active principle of the neurohypophysis reaches the autonomic nuclei in part by diffusion through the cerebrospinal fluid and in part through the blood."

PHYSIOPATHOLOGIC OBSERVATIONS

Though it is possible to understand that the autonomic nervous system controls the homeostasis of a normal individual, it is much more difficult to understand why a certain component of this system should fail. It is possible for an organic lesion to affect or destroy a part of the autonomic system. If the lesion is of an irritating character, the autonomic impulses may be intensified or increased in number. Destructive lesions would produce the opposite effects, inasmuch as nervous pathways would be destroyed or reduced in number; but in either case the muscular balance of visceral organs, vasomotor control, or glandular secretion would be disturbed. Neoplastic and vascular lesions of the premotor, motor, and hypothalamic areas with similar lesions and traumatic myelitis of the spinal cord have produced innumerable illustrations of autonomic disturbances.

again make extensive use of Cannon's¹³ excellent exposition in *The Wisdom of the Body*. The functions of the cranial division are carried out by a group of reflexes, conservative, protective, and up-building in their service. By narrowing the pupil the retina is protected from excessive light. By providing for the flow of saliva and gastric juice, and by increasing the tonic state of the gastrointestinal canal, proper digestion, absorption, and elimination of food substances are assured. Further evidence of the conservative influence of cranial autonomic tone is seen in the provision for rest and recuperation of the cardiac muscle by vagal slowing of the heart rate.

"The function of the *sacral division* is in the main to empty hollow organs which are periodically filled. Sacral autonomic impulses cause contraction of the lower colon, rectum, and urinary bladder. At the same time the involuntary sphincters of these reservoirs are relaxed. While less is known concerning the functional innervation of the reproductive tracts, it is probable that these are put in a state of sexual activity by parasympathetic impulses, as it is well known that they are inhibited by the opposed activity of the sympathetic system.

"It is apparent that these two great systems, which control the activity of our circulatory, respiratory, digestive, and genito-urinary systems, are in a state of balanced opposition. Like the balanced tone of the extensor and flexor groups of muscles described by Sherrington, when one is excited, the other is inhibited. While the effect of the sympathetic impulses is very diffuse, the opposed effect of the parasympathetic is more specific. Between the two every type of response, both general and local, is provided for. As Cannon puts it, 'all the viscera can be influenced simultaneously in one direction or the other by varying, up or down, the . . . tonic activity of the sympathetic division. And any special viscus can be separately influenced . . . by varying . . . the tonic activity of the special nerve of the opposed cranial or sacral division that reaches directly to the viscus. Thus the heart may beat rapidly because the effect is part of the total complex of effects on the viscera produced by the sympathetic in emotional excitement; . . . or it may beat rapidly without extensive involvement of other viscera because of a lessening of vagal inhibition. The sympathetic is like the loud and soft pedals, modulating all the notes together; the cranial and sacral innervations are like the separate keys. When we consider that in emergencies the sympathetic functions in a great variety of ways serve the organism as a whole, the importance of its arrangement for simultaneous and unified action becomes evident.'

"This co-ordination of the body as a whole to meet changing conditions in its external or internal environment by automatic adjustment has been called 'homeostasis' by Cannon (1929B).¹⁴ Homeostasis frees the individual from the difficult task of paying routine attention to the management of the details of bare existence. Without homeostatic control the warm-blooded animal would be in constant danger of disaster, unless always on the alert to correct voluntarily what the vegetative system regulates in a purely automatic fashion.

"All automatic mechanisms, even the most efficient, may cease to function smoothly. The normally efficient homeostatic control may break down in certain abnormal conditions. For instance, many individuals suffer from chronic vasoconstriction in the extremities; their hands and feet are constantly cold and moist from excessive perspiration. In other instances the heart may overaccelerate at the slightest stimulus, or food may fail to progress along the gastro-intestinal canal at a normal rate. When these extreme reactions continue, they result in clinical syndromes such as Raynaud's disease, neurocirculatory asthenia, and megacolon, as well as in a host of vague symptoms which cannot be classified under any definite diagnosis. . . .

pigment granules. The pigment was found to be of two types, the lipochrome or fat-containing pigment which stained with sudan III, and the fat-free type which had an affinity for silver.¹¹

From all their histologic observations Craig and Kernohan came to the conclusion that the noxious agent which caused the vascular diseases and for which operative relief had been instituted did not act on the sympathetic ganglions removed and that the ganglions act simply as relay stations for impulses from high centers where the disease originates.

CLINICOPHYSIOLOGIC OBSERVATIONS

As I observe patients with various diseases resulting from dysfunction of the autonomic nervous system, I am impressed with the fact that these individuals must be born with unstable autonomic nervous systems. Vasomotor disturbances of the extremities, when they occur, make their appearance early in life and usually afflict young asthenic females. Not infrequently some newborn infants have megacolon, and others have disturbances of the bladder and urinary retention without the presence of demonstrable etiologic factors. It would thus appear that the greater number of these individuals have an autonomic nervous system that is constitutionally inferior. They have an autonomic mechanism capable of coping with a protected environment, but they do not have one that can adjust the body to all emotions and physical demands. With the continued call on reserve energy, the autonomic mechanism of these people breaks down and produces a diseased state. It no longer serves as a regulator, but may act either as an accelerator or as a depressor mechanism.

Psychic influences play important rôles in diseases which result from dysfunction of this nervous system. Mental fatigue, worry, fear, and anger will aggravate vasomotor disturbances such as Raynaud's disease, while a change of environment, physical and mental rest, and contentment will ameliorate the symptoms.

The heat-regulating mechanism exercises considerable control over the vasomotor and sudomotor functions. Strenuous physical exercise produces a flushing of the skin and perspiration. The vasoconstrictor impulses are undoubtedly inhibited; thus arteries of the skin are permitted to relax and to increase in caliber in order to allow more blood to reach the surface, there to be cooled and to lower the body temperature. It is possible that there is a direct vasodilatation impulse which aids in affecting arterial relaxation; but, as yet, the anatomy and physiology of this phenomenon have not been indisputably settled. The excessive perspiration accounts for increased heat elimination by evaporation. Increased metabolism from excessive ingestion of food, environmental heat, hyperthyroidism, fevers and protein reaction, and artificial fevers, produce vasomotor and sudomotor responses similar to those that follow strenuous physical exercises.

Since autonomic disturbances manifest themselves in one person in the form of vasomotor spasm affecting the arteries of the hand, while in another, vasomotor spasm may be more marked in the principal arteries of the feet, and still others will complain of hyperhidrosis, essential hypertension, megacolon, and so forth, it occurred to Craig and Kernohan²¹ that it might be worth while to make a careful histopathologic study of the sympathetic ganglions and trunks which were removed for the specific purpose of effecting vasodilatation in the treatment of Raynaud's disease, thromboangiitis obliterans, the acral type of scleroderma, and the rheumatoid type of polyarthritis affecting the hands and feet. Their study consisted of a review of the sympathetic ganglions in 208 cases in which such ganglions were removed in connection with both cervicothoracic and lumbar sympathetic ganglionectomy.

According to Craig and Kernohan:²¹ "It had been noted that in a certain number of operations for the removal of sympathetic ganglions, indications of inflammatory reaction in both the posterior mediastinum and in the postperitoneal tissues were found. In the abdomen, enlarged lymph nodes frequently interfered with the exposure of the sympathetic chain to such an extent that it was necessary to dissect and remove them before the operation could be completed. Although enlarged lymph nodes were not encountered in the mediastinum, the difficulty of dissecting the sympathetic trunk due to adhesions suggested the presence of mild mediastinitis. These observations at operation raised the question of local inflammatory reaction playing some part in the dysfunction of the sympathetic system by involving the ganglion tissues and cells. In addition to the histologic examination of the ganglions removed, bacteriological examinations were also made, which were essentially negative in the entire series.

"A control series of forty nonoperative cases were used, and the corresponding sympathetic ganglions were removed at postmortem and examined in a similar manner. In none of these cases was there any clinical evidence of the four conditions which constituted the basis of this study.

"In comparing the histologic observations of the sympathetic ganglions, as evidenced by the van Gieson stain, haemotoxylin and eosin, thionin, Orlandi silver impregnation method, Hortege's silver carbonate method, Cajal's gold chloride and sublimate method, nothing was found to explain the various vascular disturbance. All the changes were within normal limits and could be explained on the basis of advancing age. There was no histologic difference between the ganglions removed for the various diseases, although these varied much in their clinical manifestations. The blood vessels in the ganglions removed from patients with vascular diseases did not partake of the changes in the blood vessels of the diseased extremity and were similar in most respects to the control vessels. Small collections of lymphocyte-like cells were present in all the ganglions, including the control ganglions. Sympathetic ganglion cells are surrounded by a delicate capsule which is covered on the outside by a layer of flattened, elongated cells of connective tissue origin and are referred to as ectocapsular cells, whereas the inner side of the capsule is lined with a layer of cells which have been called endocapsular 'amphicytes' or 'satellite cells.' There were no characteristic histologic changes in either of these groups of cells. Vacuolization was noted in all of the ganglions and was considered to be the result of acute swelling of the endocapsular cells which occasionally contain mucus. Pigment granules in the cells of the sympathetic ganglions were found to increase with the age of the patient, so that in elderly persons most cells contained numerous

pigment granules. The pigment was found to be of two types, the lipochrome or fat-containing pigment which stained with sudan III, and the fat-free type which had an affinity for silver."

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Drugs appear to have selective action on the sympathetic and parasympathetic system. Some stimulate and others depress the central activity. Other drugs appear to affect the endings of the peripheral neurones. The ingestion of alcohol, for instance, increases metabolism, but not to such an extent as to account for the sudden and marked vasomotor relaxation that it produces. It appears that alcohol stimulates the heat-regulating mechanism, which in turn inhibits the vasoconstrictor responses. The vasodilating effect of alcohol, like that of induced fever from administration of foreign protein, serves as a therapeutic agent in the treatment of vasospastic diseases.

Nerve blocks by local anesthetics produce temporary vasodilatation and cessation of perspiration. Spinal anesthetics produce similar effects over wider areas in addition to the motor and sensory anesthesia. However, a general anesthetic like ether produces a vasodilating effect which lasts from three to five days. The maximal vasodilatation response occurs as soon as the patient is thoroughly anesthetized. It then continues for from ten to fifteen hours, when the effects gradually taper off. If an operation is prolonged or much blood is lost, the protective measure of vasoconstriction overpowers the vasodilating one, and the skin will blanch and become cool and moist. The sudomotor reaction is more marked during the flushed or vasodilating phase than during the phase of shock.

VASOMOTOR REACTIONS

The rationale of sympathectomy⁴⁴ in the treatment of vasospastic disease is based on the theory that interruption of sympathetic pathways will reduce sufficient vasoconstrictor impulses to prevent vasospasm and permit return of a normal circulation.

There are two schools of thought concerning the cause of the vasospastic disease known as Raynaud's disease. The adherents to Raynaud's conception believe that vasomotor spasm involves small arteries, arterioles, capillaries, and venules, that the vasoconstrictor impulses are of central origin and are initiated by a faulty central sympathetic mechanism, and that the local reactions to cold temperatures are normal reflex responses superimposed on a state of chronic vasospasm. The other school^{38, 42} holds that defective circulation is due to a fault of the digital arteries and vessels of smaller caliber, without spasm of the veins, and that the phenomena are produced by cool temperatures and are relieved by heat.

The medical vascular and neurosurgical staffs of the Mayo Clinic have had occasion to study thoroughly, preoperatively and postoperatively, ninety-two cases of Raynaud's disease in which patients were submitted to some type of sympathectomy. The operations have varied in their scope, since they were changed from time to time during the developmental stages of the operative measures. The postoperative

results have been followed for periods of a few months to ten years. The opinions I shall give are the composite ones arrived at by the two staffs, Brown, Allen, Barker, Horton, and Roth, and Craig, Love, and myself, who have studied these cases. We neurosurgeons have also operated upon a number of other patients with diseases that are influenced by vasomotor spasm; namely, 154 patients with thromboangiitis obliterans, thirty-four with scleroderma, seven with hyperhidrosis, forty-three with peripheral rheumatoid arthritis, and thirty-six with essential hypertension. It is not the purpose of this paper, however, to discuss surgical indications and selection of cases, since it is intended to record observations to substantiate the theory that pathologic states result from a dysfunction of the central autonomic mechanism. The numerous operative procedures performed on the sympathetic nervous system have permitted me to compare the physiologic and pathologic findings before and after section of rami and removal of ganglions and trunks.

Blanching of the skin on exposure to low temperature, or on subjection of an individual to sudden fright, is a normal reaction, as is flushing of the skin when local heat is applied or when an individual is suddenly embarrassed. These normal reactions vary in individuals, and thus it is apparent that they can be initiated as easily by psychic influences as by local thermal factors. Since these same phenomena of blanching and flushing combined with sweating are important factors in regulating body temperature, it would appear that they were more or less subservient to the central heat-regulating mechanism. It is also a known fact that blanching of the skin, vasoconstriction, takes place during a chill, regardless of bed covering and room temperature, and that flushing of the skin appears during the height of fever in a cool room.

The mechanism of vasoconstriction and vasodilatation is not as simple a reaction as is contraction and relaxation of skeletal muscle, since the cardiac and vascular musculature is kept in tone by pressor and depressor substances which circulate in the blood stream. Changes in concentration of these substances will change vascular tone, but these substances are not normally secreted in such amounts as to produce pathologic lesions, unless "essential hypertension" is the result of such a condition. Thus it appears that a direct neurogenic vasoconstrictor impulse is necessary to produce sufficient vasospasm to decrease the blood supply until death of tissue results.

RAYNAUD'S DISEASE

Since Raynaud's disease^{1, 2, 3} represents the typical phenomenon of vasospasm, which varies in degree from mild discomfort to ulceration, gangrene of digits with scleroderma,⁴ and dactyle arthritis,⁵ it will serve as the theme for discussion. Its amenability to various forms

of sympathectomy permits of preoperative and postoperative studies. One might try to present a composite picture in chart form of all our cases in which operation has previously been performed. Since the symptoms and reactions are similar, however, only varying in degree of severity, I believe the facts can be told more clearly by following the record of one case which presents most of the problems encountered in the treatment of vasospastic disease.^{4, 5, 9, 26, 55, 57}

If we were to accept the theory that the changes in color of Raynaud's disease were due to a fault in the terminal arteries of the digits or in the smaller arteries of the skin, instead of a fault in the central mechanism, we would expect no psychic influences on these changes in color, nor would we expect the phenomenon of asphyxia or cyanosis to appear in patients residing in warm climates or living in an overheated room. Neither would we expect nerve block or interruption of postganglionic rami, various forms of sympathectomy, to alter the cycle of asphyxia, cyanosis, and rubor in patients, assuming of course that the environmental temperatures were the same postoperatively as they were during the tests taken preoperatively:

TYPICAL CASE OF VASOSPASTIC DISEASE.—A school girl, seventeen years of age, first registered at the clinic in March, 1926. She was native born of English descent. Her chief complaint was of drawing pains in the right lower abdominal quadrant. She was also troubled with constipation, frequent headaches, and insomnia. General examination revealed nothing definite, and the neurologist concluded that she was suffering from nervous exhaustion, since the laboratory and physical examinations revealed no evidence of Raynaud's disease or of any other physical defect. It was apparent that the patient at this time was having difficulty in adjusting herself to her environment, as it had become necessary for her to stay out of school two or three days every week.

The patient again reported in March, 1932, with a history of vasomotor disturbance, complaining of whiteness and tingling of her fingers and toes; she did not complain of abdominal discomfort, headaches, constipation, or insomnia. She stated that she had first noticed these symptoms in the autumn of 1927, about eighteen months after her original visit to the clinic. As she went on to describe the onset of her symptoms, she stated that the first observations made were that, on awakening in the morning, the tip of her third finger on the left hand would become white, numb, and would tingle. Two or three months later she had noticed that the whole finger had become involved instead of just the tip. She said that she had been able to see the white line gradually advancing toward the hand. The changes in color, those of asphyxia, had lasted from three to thirty minutes, and at first had occurred only in the morning. In the spring of 1928, her big toe on the left foot had blanched, become numb, and tingled, simultaneously with similar symptoms in the third finger of the left hand. Within two months of the onset of the vasomotor changes in the big toe, all her toes and fingers of the left foot and hand, with the exception of the thumb, had gone through the same changes. In the autumn of 1928, the third finger on her right hand and her big toe on the right foot had been affected in a manner similar to that which had affected the corresponding fingers and toes of the opposite side. Two months later all of the toes and fingers on the right side had become involved, but the vasomotor reaction to asphyxia, that is, blanching, numbness, and tingling, had been still more intense on the left side than on the right. The patient said that there was no prickling sensation during the red

phase. By this time her typical attack consisted of a blanching period, of three to thirty minutes, which was followed by blueness of thirty seconds' to two minutes' duration and redness of thirty seconds' duration. She said that the longest white stage that she had ever experienced was that of two hours, and that it had affected her left big toe alone. She also said that the attacks of asphyxia, cyanosis, and rubor with the accompanying pain had been more prone to occur during damp weather or cold weather, especially so when she had been either physically or mentally fatigued, and that she had felt most comfortable when the climate was dry and warm.

On physical examination in March, 1932, at which time the patient was twenty-three years of age, she was five feet and three inches tall and weighed 105 pounds (47.6 kg.). Her normal weight should have been 120 pounds (54.4 kg.). The systolic blood pressure was 140 and the diastolic 96. She was anemic and asthenic in appearance, and had hypertrophied tonsils, but without evidence of free pus. Examination of her heart and lungs gave negative results. Examination of the abdomen and pelvis was also negative. The patient's hands were cold and clammy but were normal in color; her feet were cold but dry and presented a slight rubor over the toes. All the principal arteries of the extremities were open and pulsated normally. There was no evidence of scleroderma or arthritis. Special examinations such as roentgenologic examinations of the lungs and spinal column, and examinations of the eyes, ears, and central nervous system were negative.

Examination of the blood revealed 4,610,000 erythrocytes and 7,300 leucocytes per cubic millimeter, and the value for hemoglobin to be 97 per cent. A flocculation test for syphilis was negative. Microscopic studies of the capillary loops at the nail folds showed the capillaries to be dilated and tortuous. The specific gravity of the urine was 1.024; it was acid in reaction, contained no albumin or sugar, and on electrocardiographic studies revealed sinus arrhythmia, slight right ventricular preponderance, a diphasic T-wave in derivation III, a transient exaggerated P-wave in derivation II, a notched P-wave in derivation II, and a slurred QRS in derivations I, II, and III.

Vascular studies were made on March 29, 1932, to determine the absence or presence of vasomotor spasm. The history of the attacks of blanching, blueness, and redness was rather typical of Raynaud's disease, although the patient could not produce the color changes as readily as many patients do in meeting strangers during the examination. The vasomotor studies definitely demonstrated that there was present a marked vasospasm in all fingers and toes. On the morning of March 29, at about 8 A.M., the patient was given an intravenous injection of Lederle's triple typhoid vaccine of 20,000,000 bacteria. The initial skin temperature read by the electrothermocouple was 22.1° C. for the left big toe, 22.2° C. for the right big toe, 25.0° C. for the right third finger, and 23.4° C. for the left third finger. At the height of fever reaction, the skin temperatures had risen to 34.5° C. for the left big toe, 34.8° C. for the right big toe, 37.2° C. for the right third finger, and 36.9° C. for the left third finger. This revealed an average rise of 12° C. temperature above the initial skin temperature before the injection of the vaccine. The fever reaction was rather mild owing to the rather small dose of vaccine employed, but since the surface temperature of the skin over the toes and feet rose so high, it became apparent to us that there existed a very marked vasospasm and that we were justified in advising and performing sympathectomy. Inasmuch as the symp- toms involving the feet interfered with the patient's getting about, it was decided to perform bilateral lumbar sympathectomy first. However, in view of the fact that some investigators have reported improvement in the vessels affected by vasospasm from roentgen therapy, as well as from roentgen treatment of the cervical ganglion, it was concluded that it might be well to give a course of treatment to the hands.

before lumbar sympathectomy. Accordingly, on March 23 the patient received on each hand 275 roentgen units of high-voltage roentgen rays, or in other words one-half the erythema dose. She reported for a second course of roentgen treatments on June 3, 1932, and the roentgenologist, Dr. Desjardins, commented that little or nothing would be accomplished by roentgen treatments of the blood vessels of the hands, but that it might be well to continue with the proposed plan. The patient again received roentgen treatments of one-half the erythema dose, but this time the treatment was applied to the cervicothoracic region. She reported a third time, on July 1, and was given one-half of an erythema dose to the right hand. Subsequent follow-up studies showed that no improvement followed these roentgen treatments.

Bilateral lumbar sympathetic ganglionectomy and trunk resection, including the second, third and fourth lumbar ganglions on both sides, was performed April 1, 1932. There was nothing unusual about the ganglion operation or abdominal exploration. The patient's convalescence was uneventful and the result was satisfactory. The skin over the feet and the legs up to the knees became warm and dry and appeared slightly more pink than that of a normal individual. The patient's symptoms affecting the feet disappeared. The patient was cured and has had no evidence of any return of her symptoms in the feet. The color changes of asphyxia, cyanosis, and rubor have never reappeared, regardless of exposure to cold and damp weather; they have not occurred when the feet have been immersed in ice water, nor have they occurred from psychic influences.

The successful result of the lumbar sympathectomy encouraged one of the neurosurgeons to advise and carry out cervicothoracic sympathectomy, and this was performed September 24, 1932. Since difficulty was encountered at the time of operation, and the operation was not made as complete as it usually is, I shall take the liberty of quoting from the surgical record, since the surgeon who operated on this patient anticipated an incomplete surgical result. The surgical approach was a posterior one through a midline incision in the skin from the spine of the sixth cervical vertebra to that of the third thoracic vertebra. The aponeurosis of the trapezius, rhomboid, and serratus posterior muscles was reflected on both sides of the spinal column. The entrance on the right side into the postmediastinal space followed resection of a portion of what was supposed to be the first rib adjacent to and including the tip of the transverse process of the corresponding vertebra, but, instead, the entrance was through the second rib and exposure resulted in opening of the pleura. The opening was promptly closed by a stitch of catgut. The operation was continued. However, the entrance into the mediastinum by the way of the second rib not infrequently results in opening of the pleura, which can be obviated by entering the mediastinum following resection of the first rib. Though the entrance through the second rib permits removal of the first and second thoracic ganglions, it does not always permit removal of the lower cervical ganglion, the upper component of the stellate, or does it allow for division and ligation of the superior intercostal artery with its accompanying rami or permit as thorough ramisection of the lower trunk of the brachial plexus as is obtained by entrance into the postmediastinal space by the way of the first rib. This situation developed in this particular case.

At the same operation, following completion of the unsatisfactory sympathectomy in the right cervicothoracic field, left cervicothoracic sympathectomy was performed, employing the approach into the mediastinum through the space occupied by the resected portion of the first rib. The mental hazard of encountering difficulty on the right side more or less limited the activities on the left side and the surgeon was satisfied to remove only the cervicothoracic ganglion and intervening trunk without dividing the superior intercostal artery or the rami accompanying it and the rami ascending to the lower trunk of the brachial plexus from the second and third thoracic ganglions on the left side.

Postoperative convalescence was satisfactory in that the vasomotor symptoms were much improved; they were not completely relieved, however, inasmuch as localized areas of sweating persisted (Fig. 1), and slight changes in color would appear in limited areas. The symptoms were more marked on the dorsum of the left wrist which suggested that an incomplete operation had been performed. Very soon after operation, however, a sweating area appeared on the dorsum of the left wrist which suggested that an incomplete operation had been performed. In view of the surgical experience in the right cervicothoracic field, the surgeon advised reexploration of that wound, and this was carried out on October 10, 1932, this time resecting a proximal portion of the first rib and transverse process preliminary to entering the mediastinum. Numerous adhesions were encountered which

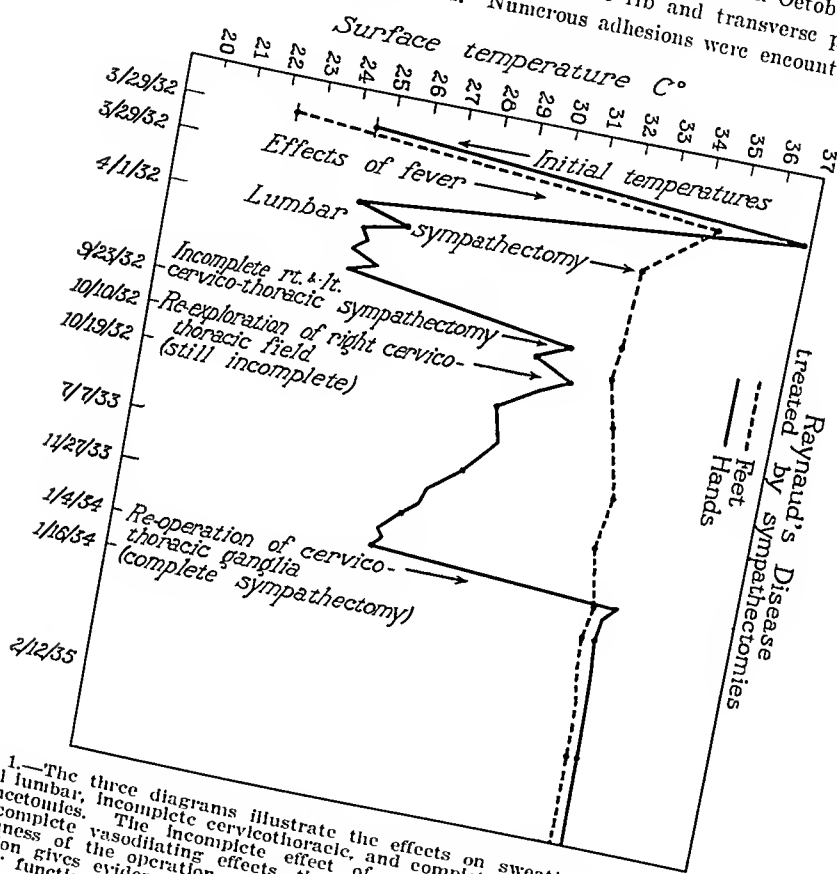


FIG. 1.—The three diagrams illustrate the effects on sweating which result from bilateral lumbar, incomplete cervicothoracic, and complete cervicothoracic sympathectomies. The incomplete effect of sympathectomy is always associated with incomplete vasodilating effects, thus it serves as an indicator concerning the thoroughness of the operation. Skin over areas not deprived of their sympathetic innervation gives evidence of increased sweating which appears to take on a compensatory function.

were due to the former operation, so that the surgeon again experienced unusual difficulty in completing a thorough an operation as is usually performed.

The patient made an uneventful convalescence and was dismissed. In the winter she had occasional episodes in the morning when blanching would occur in localized areas over the fingers, which were followed by but slight cyanosis and a short period of redness. There was no true pain, but there was some tingling in the fingers. She complained of excessive sweating over the trunk and especially about the waist. Sweating tests were made on her return, at this time, and they revealed

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thorotrast has filled the arteries to their peripheral ends. The fact that the recurrence of symptoms increased in severity as time elapsed following operation raised the question by the medical staff as to whether or not regeneration of sympathetic pathways was not taking place.

This discouraging experience did not dissuade me from advising reexploration of the right and left cervicothoracic fields, for I had had previous experiences in which I had found the sympathetic fibers at the second operation that had been overlooked at the former operation. The very fact that I have never seen recurrence of symptoms in a case of Raynaud's disease or any nonocclusive vasospastic disease of the lower extremity following successful lumbar sympathetic ganglionectomy made me believe that I should accomplish the same results in the treatment of Raynaud's disease of the hands or face if I were able to interrupt successfully all sympathetic pathways carrying vasoconstrictor impulses to the blood vessels of the hands and those that supply the face, brain, and other special organs. I believed that the progressive recurrence of symptoms was not the result of regeneration of new fibers, establishing new synaptic connections in sympathetic ganglions and neurones which were probably injured by retraction, but were not actually divided and removed.

Therefore, in the light of my former experience and my conviction concerning the central influence on vasospasm of peripheral arteries, I advised and performed the fourth sympathetic operation, employing the old cervicothoracic wound and re-entering the mediastinum on the right and left sides,² respectively. This was done January 4, 1934, in midwinter. The only change I made in the approach was to increase the opening by resecting an additional portion of the first rib in order to have an opening 3 cm. in length extending from the body of the rib which articulates of the resected rib. As a rule I never remove the head of the rib which articulates with the body of the vertebra. I leave this small nubbin which measures about 7 mm. in its long axis. By careful dissection, I proceeded with exposure of the respective fields. This exposure allowed me to enter the thoracic cavity from behind through a space between the lower cervical and first thoracic nerves making up the lower trunk of the brachial plexus. On account of the scar tissue, I took special pains in conducting a careful and thorough dissection to avoid injuring or opening the pleura and to avoid injuring the brachial nerves. The first important finding observed on entering into the left cervicothoracic field was that the superior intercostal artery and its accompanying rami had not been divided, and I also found the brachial plexus. There also remained some communicating fibers that had circumented the true cervicothoracic trunk to enter the upper portion of the lower cervical ganglion, which had been resected at the former operation. In order to assure myself still further, I carried out removal of the second thoracic ganglion on the left. The findings on the right side were very similar to those on the left, with the exception that it appeared as if the cervicothoracic trunk had been divided below the lower cervical ganglion. This can easily occur if one attempts to remove the cervicothoracic ganglion by an intrathoracic approach through the second rib. The reverse often takes place; namely, removal of the cervical ganglion when an attempt and leaving the thoracic portion of the so-called stellate ganglion and overlooking the third thoracic ganglion. There remained, as we suspected, uninterrupted postganglionic rami extending from the intercostal artery. I expressed the opinion immediately following the operation that I believed that the operation should be successful, and the results should be similar to those accomplished in the feet, for I had removed as far as I could observe every possible postganglionic ramus that could possibly enter the nerves to the brachial plexus.

irregular sweating areas, more in number over the right hand than on the left. Vasomotor studies were made and now demonstrated that definite changes in color could be obtained by the ice water and psychic tests, but the range of color differed from that prior to surgical interference, since it now extended from a mild pallor to rubor and back to normal, eliminating the cyanotic phase. The episode of color change and discomfort was much less, and the patient volunteered the opinion that the improvement at this time was equivalent to from a 50 to 75 per cent cure.

The patient returned for another examination on November 6, 1933. (She lived but forty miles from the clinic and it therefore was rather convenient for her to return for these numerous observations, and she was hoping for relief in her hands equivalent to the relief obtained in her feet following lumbar sympathectomy.) Numerous studies of temperature were made, the results of which are presented in chart form for the sake of clarity and brevity (Fig. 2). The patient reported on this visit that all the fingers of both hands had become cold rather easily, that the

Raynaud's Disease

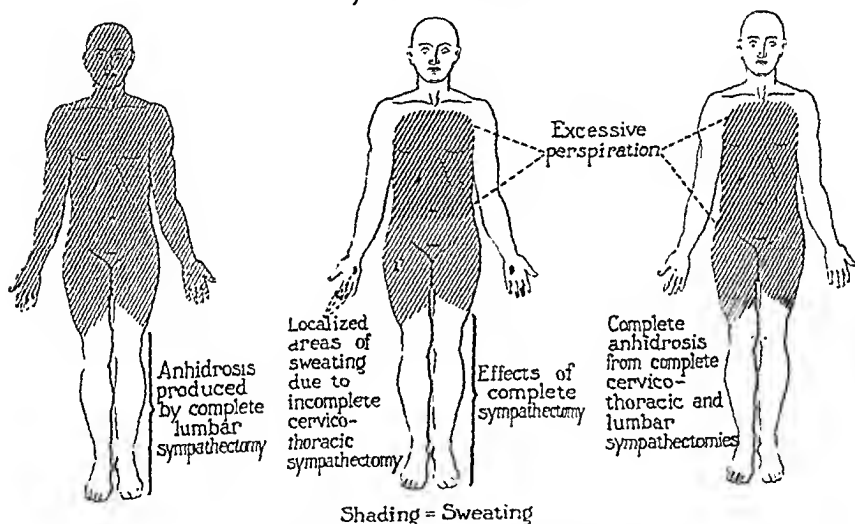


Fig. 2.—The initial and subsequent skin temperatures produced by fever and by complete lumbar sympathectomy, showing the effects produced by incomplete and complete interruption of vasomotor fibers to the terminal arteries of the digits in terms of skin temperature. These readings extend over a period of approximately three years. The permanency of the vasodilating effects produced is illustrated by these successful sympathectomies.

third finger on the left and second and third fingers on the right hand had become pale on exposure to cold, following which they had become red and had tingled before returning to normal. She further stated that at times all the fingers on her right hand except the thumb had become pale on exposure to cold. These findings suggested to me that the original cervicothoracic sympathectomies were incomplete, and I therefore advised the fourth operation: reexploration of the cervicothoracic fields and complete interruption of all vasomotor fibers to the hands.

The studies with thorotrast (Fig. 3) made by Allen revealed such attenuation of the digital arteries that it raised the question as to whether or not Raynaud's disease of the hands might be a different lesion than the one that affects the feet. However, subsequent thorotrast studies (Fig. 4) following the fourth sympathetic procedure disclosed the fact that these attenuated vasospastic arteries were thoroughly dilated by sympathectomy, and, on observation of these films, it is readily seen that the

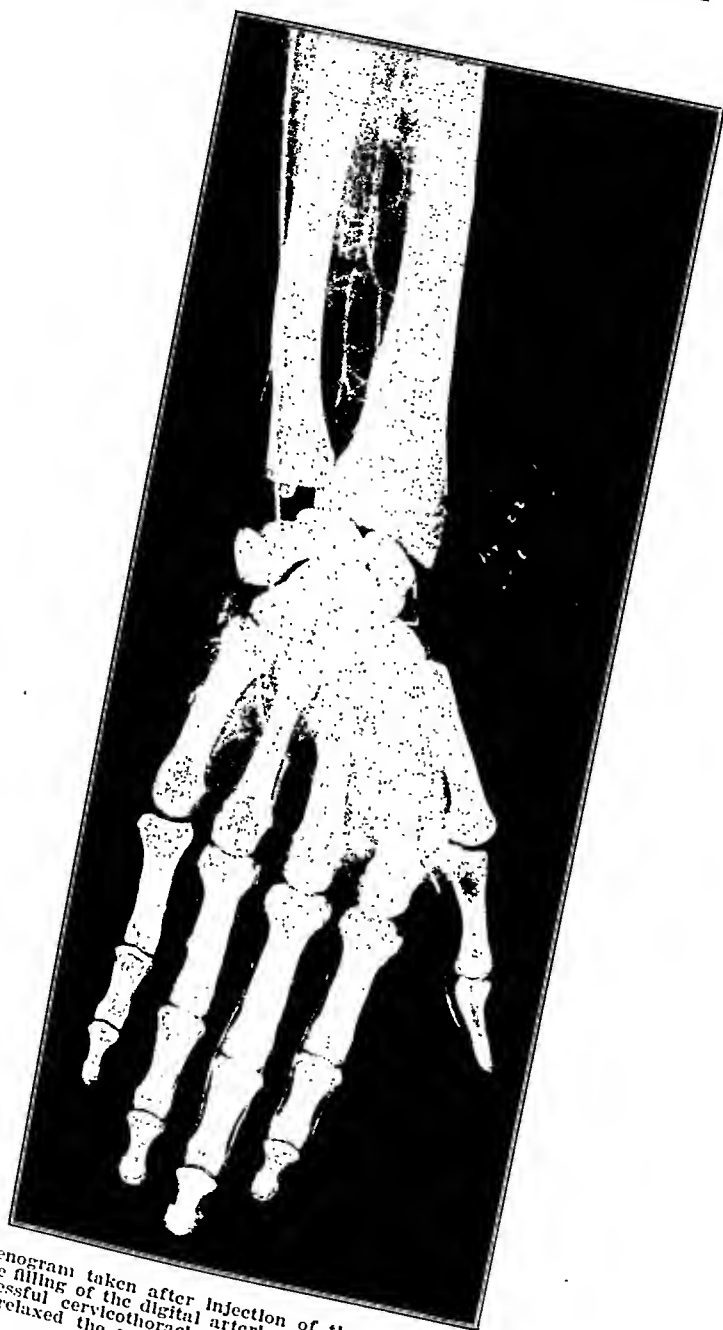


FIG. 4.—Roentgenogram taken after injection of thorotrast (Jan. 22, 1934). Illustrating the complete filling of the digital arteries to the fingers of the hands following thorough and successful cervicothoracic sympathetic ganglionectomy and trunk resection which has relaxed the vasomotor spasm of the digital arteries (loaned by E. V. Allen).

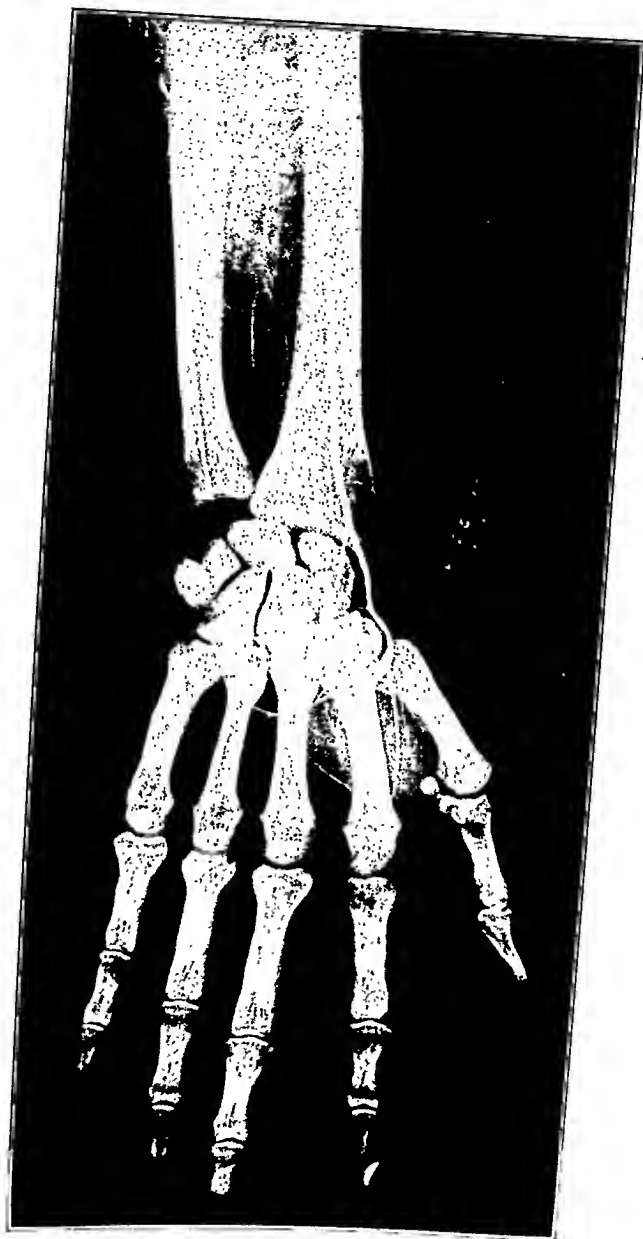


Fig. 3.—Roentgenogram taken after injection of thorotrast (Nov. 27, 1933), illustrating the incomplete filling of the digital arteries due to vasomotor spasms. These were taken following the two incomplete cervicothoracic operations, just prior to the last thorough and successful cervicothoracic sympathectomy (loaned by E. V. Allen).

mitted to cold atmospheric temperatures of zero weather, the individual with Raynaud's disease who is suffering with chronic vasospasm will complain bitterly of pain in the fingers and hands and sooner or later develops ulcers on his finger tips, whereas the normal individual would experience but slight discomfort.

Frequently we have seen patients suffering from mild Raynaud's disease improve when they have changed their vocation or worn heavier clothing, such as mittens and overshoes, or moved to a warmer climate. Equally as often we have seen the disease develop in individuals living in extremely hot climates and seen it fail to improve in patients who have moved from colder to warmer climates, which compels us to conclude that the cold temperatures only set up vasomotor reflexes that aggravate existing chronic vasospasm, and that the fault is due to some other cause than a peripheral one in the small arteries. The beneficial effects of changing one's vocation and the amelioration of symptoms which result from the removal of annoying influences connected with the previous vocation or environment suggest that the causative factors may be of a psychic or a constitutional nature. The psychic or emotional influence is borne out still further by observing patients under different degrees of room temperature. The first meeting with the patient in the office where the temperature is 72° F. or warmer, depending on the season of the year, invariably causes the patient's hands or feet to undergo changes in color. Areas on one or more fingers will blanch, become blotchy, and present an area of asphyxia, with an alternating area of cyanosis. The process may shift from finger to finger, or include all the fingers and toes and even a good portion of the hands and feet. Repeated visits result in less emotional strain and in less pronounced changes in color. Excitement, however, and the meeting of new people, cause the symptoms to repeat their cycle.

In our endeavor to relieve these patients of their symptoms, we have performed numerous tests, as have many other investigators, for the purpose of investigating and relieving the phenomena of vasospasm. The injection of a nerve with a local anesthetic agent, as Lewis⁴³ and Scott and Morton⁴⁵ have done, will produce complete vasodilatation of the digital arteries and the smaller arteries of the skin if the peripheral nerve selected carries all of the vasomotor fibers to the digit studied. Otherwise, the vasodilating effects and the thermal skin temperatures will not reveal the true results of nerve block or interruption of all vasoconstrictor impulses to the dermal field under study. An accurate way to determine the effects of a local anesthetic, 1 per cent procaine solution, is to inject a ring of anesthesia about the base of a finger of a patient who is suffering from the typical color changes of Raynaud's disease. One should wait until the fluid has diffused and the finger becomes completely anesthetized before carrying out the tests. In the first place the skin temperature over the tip of the finger will record a

The wound was closed and the patient returned to her room. Within an hour following the return to her room, the patient was awake and rational and conversed with me when I called on her before leaving the hospital. As I entered the room she extended me her hand and said that her hands now felt like her feet did ever since the first operation. On asking her what sort of feeling this was, she replied that the tightness or drawing sensation had disappeared.

The patient's convalescence was uneventful and postoperative results were extremely satisfactory. Repeated examinations, which have carried her through the spring months of 1934 and the winter and spring months of 1935, have shown that the patient's symptoms in her hands have completely disappeared and have not returned since the last major and complete bilateral cervicothoracic sympathectomy (Fig. 2). The hands are warm, slightly pink, and dry. There has been no return of the symptoms of Raynaud's disease, color changes, pain, or trophic disturbances. She reported that since this last operation she has been able to take part in winter sports, has gone out and deliberately shoveled snow in a snowstorm without any of the untoward results. Thermal studies reveal the continued increased skin temperature. Studies of the capillary loops at the nail folds still show them to be slightly enlarged, but they are much smaller than the dilated loops during the cyanotic stages and only slightly larger than normal capillary loops. The patient has in addition to her vasomotor relaxation a definite bilateral Horner's syndrome, which is not conspicuous when it is bilateral and equal and which does not interfere with her vision. The retinal vessels showed a definite increase in the size or caliber following the successful sympathectomy, suggesting evidence that the postganglionic fibers carrying vasoconstrictor impulses have been interrupted. These fibers are included in the sympathectomy when attempting to denervate thoroughly the blood vessels of the arms and hands. There is present a moderate congestion of the mucous membranes of the nose and throat. The patient is conscious of this and at first thought she was catching a cold, but she was willing to accept the slight discomfort in lieu of the pain and disabling symptoms of Raynaud's disease. The postoperative studies¹⁰ with thorotrast also revealed definite relaxation and an increase in the caliber of the terminal arteries to the digits and to the small arteries of the skin.

The experience encountered in connection with the treatment of Raynaud's disease in the lower and upper extremities suggests that the same disease affects both the upper and lower extremities, that the vasospasm is under a central control, which, if ablated by interrupting sympathetic pathways, will disappear, and that the disappearance of vasospasm results in a cure. This cure is effective only when the operation is extensive and complete and when fibers are not overlooked. Similar operations are indicated in other diseases, such as thromboangiitis obliterans, scleroderma, and rheumatoid arthritis, of the smaller joints, and those of the hands and feet when there exists a definite vasospastic factor and when the vascular study reveals a favorable skin temperature rise on administration of protein.

In studying patients with vasospastic lesions, such as in Raynaud's disease, it is observed that local cold stimuli, immersion of hands in ice water for one minute, will produce the marked color changes of asphyxia followed by cyanosis and rubor. On submitting normal individuals to the same tests, one observes that the blanching is less, that no cyanosis appears, and that only moderate redness follows the return of normal skin temperature. If both individuals are repeatedly sub-

mersed in ice water or exposed to cool atmospheric temperatures. It is also observed that the psychic influence producing changes in color has also been lost during the height of fever. The fever reaction, however, must be a brisk one of at least a rise in temperature of 3 to 4° C., by mouth, in order to produce a thorough vasodilating effect.

The vasodilatation effect relieves the patient of all symptoms. Surgeons have therefore tried to reproduce these same effects. We have learned that if it were possible to raise the skin temperature of the affected digits to a degree at least twice as high as the rise of the mouth temperature, by the administration of protein, we could expect the same symptomatic relief as is obtained by the fever test or vaccine treatment.

CHOICE OF OPERATIVE MEASURES

I hope it is clearly understood that I never advise or perform sympathetomy in a case in which the disease is mild or is readily controlled by medical management. It is performed only when the disease is progressing in spite of medical measures, and when the vasodilating tests, preferably the fever tests, indicate a favorable dermal rise in temperature, on the theory that the increased skin temperature is a definite expression of increased blood flow due to vasodilatation from relaxation of arterial spasm.

The earlier investigators attempted to produce the vasodilating effects by periarterial sympathetomy. The operative results were incomplete, but the conception propounded by Leriche and Fontaine⁴² of paralyzing the vasomotor control to peripheral arteries has been repeatedly verified. Royle's⁵⁴ ramisection represents another step in the surgical development. Though his operation was more extensive in scope than periarterial sympathetomy, it did not originally include sufficient rami to denervate thoroughly the vessels to an extremity. It was for that reason that I suggested and performed extensive forms of sympathetic ganglionectomy and trunk resection with the hope of thoroughly interrupting the impulses of vasoconstriction.

The bilateral lumbar sympathetic ganglionectomy which includes the second, third, and fourth lumbar ganglions on both sides, with the intervening trunks, interrupts all vasoconstrictor impulses leaving the lower end of the thoracolumbar outflow to the feet and lower part of the legs.⁵⁴ Simple division of the lumbar sympathetic trunk below the second lumbar ganglion would be sufficient if the distribution of fibers were constant, but since some may descend from higher ganglions and escape the trunk below the second ganglion, it becomes necessary to carry out more extensive operation to interrupt thoroughly postganglionic rami carrying vasoconstrictor impulses.

In nonocclusive diseases like Raynaud's disease, the skin temperature promptly increases following sympathetomy. The rise immediately

3 to 10° C. rise over the dermal temperatures taken prior to the injection. The skin of this finger will not change color as it does on the other fingers of the same hand when immersed in ice water. It no longer reacts to emotional stimuli like its fellow fingers. Thus it appears that not only the autonomic reflex arc has been broken by the anesthetic, but that the central impulses initiated by psychic factors are also blocked. This suggests that the mechanism of vasospasm of digital arteries and terminal arteries in the skin is not confined to a peculiarity or fault in the artery, but that it is controlled by a central mechanism and is modified by the dermal reflex.

Numerous similar local and general tests have been employed to determine the degree of existing vasospasm and whether it was possible to relieve this vasospasm to justify surgical measures for interrupting the sympathetic pathways. The simplest tests consist of comparing the dermal temperatures over the digits before and after the body has been warmly covered.¹⁹ The increase in skin temperature records in a general way the increased flow of blood to a digit or extremity. The covering tests, however, are not very accurate as they do not always release the psychic factors. Local or regional anesthetic blocks are probably the most accurate tests employed if the investigator makes sure that the dermal area to be studied is thoroughly deprived of all vasoconstrictor impulses without infiltrating that area. Patients dislike multiple injections, however, and this test therefore fails to meet all the demands. The administration of 2 ounces (60 c.c.) of alcohol by mouth produces a sharp vasodilating effect, but it, too, is not as reliable as the effects produced by intravenous injection of a foreign protein. The dose and method used depend on the nature of the substance, the size of the patient, and the reaction desired. An average dose is Lilly's antigen H. or Lederle's triple typhoid vaccine of 25,000,000 to 75,000,000 bacteria. A chill may precede the rise in body temperature, but, if it does, it is of short duration and the investigator will be assured of a maximal rise in temperature within three to four hours after the injection. Again, numerous procedures and devices, such as oscillography, calorimetric studies, observation of blood flow in the capillaries in the nail fold, and temperature studies of the skin over the various digits are employed to calculate the changes in blood flow produced by induced fever. As previously stated, the fever is a manifestation of increased metabolism. The increased metabolism results in heat production. Thus, the heat-regulating mechanism through its plexiform arrangement in the medulla proceeds to disperse the increased body heat by dilating peripheral arteries, which permits the blood to reach the surface and to become cooled.

By studying the effects of fever on a patient with Raynaud's disease, it is observed that, during the height of fever, none of the fingers or toes are capable of going through the cycle of color changes when im-

constrictor impulses and consequently have been divided. I am inclined to believe that the vasodilating mechanism is one of inhibition of the autonomic centers, a phenomenon we reproduce by sectioning sympathetic pathways in interrupting vasoconstrictor impulses to the arteries, capillaries, and veins. I believe these postoperative observations support most strongly the theory that exaggerated vasospasm, vasospasm of such a character as to interfere with the blood supply of tissues, is a fault of the central mechanism, and that the postganglionic rami convey such vasoconstrictor impulses to all arteries, but that disease results only when the smaller arteries are affected.

This opinion is further supported by experiences observed in connection with the development of operations on the sympathetic nerves to the vessels of the upper extremities. Several of the earlier operations were incomplete and, consequently, the results were incomplete. At that time this suggested that perhaps Raynaud's disease of the hands was different from that of the feet. As I changed the operative approaches and increased the scope of the surgical field to assure complete interruption of all sympathetic rami carrying vasoconstrictor impulses to the vessels of the hands, the same satisfactory results obtained following lumbar sympathectomy were reproduced in the hands. The real test came, however, when I operated again in those cases in which I and others had failed to give complete relief by incomplete sympathectomy. The case reported, with its multiple operations, is one of several which supplies the evidence that if the surgeon overlooks fibers or carries out a limited operation on the cervicothoracic ganglions, trunks, and rami, incomplete results will follow, and that complete extensive operations will give satisfactory results. I have had failures following cervicothoracic sympathectomy, but they have not occurred of late when I have done a complete operation unless there was an advanced coexisting scleroderma or extensive trophic changes. These trophic changes produce strangulation and thrombosis of the distal portions of the smaller arteries, to such an extent that vasodilating procedures are ineffective since the few remaining arteries are either unable to dilate or are too few in number to increase the blood supply sufficiently to bring about restitution of the tissues. In the earlier phases of this type of surgery we had to learn by trial and error, but today we rely on vasomotor studies, as we learned that those who respond favorably to fever therapy will respond favorably to properly planned and executed forms of sympathectomy.

ESSENTIAL HYPERHIDROSIS

Of interest is that small group of individuals who have such excessive perspiration of the hands, and occasionally of the arms, face, and feet, that it interferes with their economic and social existence. It prevents them from working on books and from handling fine fabrics, and

after operation is as high as that produced by fever from administration of protein. In two or three days it falls, with the cessation of post-operative fever, to a level of 1° to 3° C. below the high point during the fever studies. It remains there indefinitely, for Brown and his staff have rechecked these patients again and again at varying intervals following operation. Environmental temperatures influence the sympathectomized area less than they do normal skin, but, to assure constant readings, an air-conditioned room is necessary for temperature studies. We also prefer to use an electrothermoeouple, with numerous electrodes, which can be taped to the finger tips and to other areas of skin without moving or disturbing them throughout the test. These readings not only give information concerning the general vasodilating effects, but indicate the status of individual digits. In cases in which the skin temperature fails to rise under fever studies, it will likewise fail to rise following sympathectomy and the patients will fail to receive the beneficial effects of the operation.

Postoperative observation of the feet reveals that the skin is much warmer than that of the nonsympathectomized area over the hands. It is dry and does not sweat since the sympathetic fibers to the sebaceous and sweat glands have also been divided in the lumbar sympathectomy as they intermingle, and they are so closely associated with those carrying vasomotor impulses that it is impossible to separate them. The skin is slightly pinker in color than normal skin. Microscopic observation of the capillary loops at the nail folds reveals that the loops that were dilated before operation have returned to normal size and that the corpuscles are passing through at a greater rate of speed than they did when the skin was in the state of asphyxia or cyanosis. Prolonged and marked cyanosis results in some permanent change in the capillary loops. In those instances they will contract some, but are unable to return to normal size, which explains the phenomenon of the appearance in a few cases of bright red finger tips following sympathectomy.

The four most interesting observations following sympathectomy are: (1) failure of the skin to undergo changes in color during exposure to ice water or to cool temperatures, (2) its failure to repeat color changes when the patient becomes excited or is under emotional stress, (3) relief of local pain and recovery of trophic changes, and (4) the measurements of retinal arteries and veins before and after successful cervicothoracic sympathetic ganglionectomy and trunk resection reveal an actual increase in diameter, following the operation, of one-fourth to one-half of that of a normal vessel. Following successful cervicothoracic sympathectomy, the patients are no longer able to blush when embarrassed, which phenomenon suggests one of several possibilities: first, the lack of a definite vasodilating mechanism; second, the absence of antidromic vasodilator fibers in the sensory peripheral spinal nerve, and third, that fibers carrying vasodilator impulses travel with those that carry vaso-

two stages, and there are two separate incisions. It consists of sub-diaphragmatic, retroperitoneal exposure and resection of all splanchnic trunks as they perforate the diaphragm to enter the abdominal cavity, and removal of the first and second lumbar sympathetic ganglions to interrupt thoroughly the last two white rami of the thoracolumbar outflow and to permit exploration or resection of the suprarenal gland.²⁵ At this later operation all sympathetic rami below the diaphragm are sectioned except for an occasional fiber that follows the aorta through the diaphragm. It permits thorough denervation of the suprarenal gland by sectioning the rami at their source before entering the capsule.

The clinicophysiological observations²³ following these two extensive forms of sympathectomy are very similar. The patients are relieved of headache and precordial distress. They feel more comfortable; however, they have lost some of their drive or endurance. Their blood pressure, immediately following operation, will often drop as much as 100 mm. Hg under the preoperative readings, but as the patients convalesce and are able to be up and about, it gradually rises to a constant mean curve which has a systolic drop of 44 mm. and a diastolic drop of 38 mm. Following rhizotomy, the abdominal muscles are paralyzed. This accounts for the sagging of abdominal muscles which has to be corrected by an abdominal binder. In some instances the systolic blood pressure has dropped below 100 mm. when the abdominal binder was removed and the patient was in the upright position. These extensive forms of sympathectomy result in vasodilatation and in increased skin temperatures of the feet, legs, and body below a transverse line placed midway between the ensiform cartilage and umbilicus. The cessation of sweating begins at the same line and extends to the feet. The urogenital mechanism of ejaculation is lost, but the libido and potentia are preserved in males. There is no pathological disturbance in the retention or evacuation of urinary or fecal contents. However, in light of our experiences with the treatment of Hirschsprung's disease and cord bladder, I would be inclined to expect evacuations to be more frequent after operation than they were before. The operation has not disturbed the menstrual cycle. None of the females has desired pregnancy so I am unable to state whether or not the operation would interfere with a normal one. I am inclined to think it would not, since the effect is similar to presacral neurectomy, which has not prevented nor disturbed normal pregnancy. Men, of course, become sterile unless there should be a spontaneous seepage of seminal fluid, since there is no ejaculation with the orgasm.

CONGENITAL MEGACOLON AND BLADDER PARALYSIS

The factors producing, and the results obtained by sympathectomy in the treatment of, congenital megacolon,^{3, 36, 51, 56} congenital bladder paralysis and paralysis of the bladder resulting from injury to the

also ruins their clothing, gloves and shoes. Those who are more timid are constantly embarrassed in meeting strangers or in associating with the opposite sex since their hands are always dripping wet. Inasmuch as the sudomotor fibers were included in the various types of sympathectomy designed to relieve vasomotor spasm, it became apparent that the same operation could be employed to correct hyperhidrosis. The result is extremely satisfactory since the skin promptly becomes dry and remains so permanently. Excessive perspiration accompanies vasomotor reactions which manifest themselves in cool or hot, wet hands. At no time have the color phases become as marked as to resemble true Raynaud's disease. However, excessive moisture on the skin is frequently present with symptoms of Raynaud's disease, but it is never so excessive that it drips from the fingers or toes as it does in essential hyperhidrosis.

An unusual observation is that perspiration will be increased over the trunk (the chest, back, and abdomen) following bilateral cervicothoracic sympathectomy, and especially so if the patient has also undergone bilateral lumbar sympathectomy, regardless of the disease for which these operations were performed. The increase of perspiration in non-sympathectomized areas appears to be a compensating phenomenon of the heat-regulating mechanism, signifying a central control of the sudomotor fibers.

Clinically, this excessive perspiration about the chest is cared for by encouraging the patients to wear a sleeveless silk and wool undershirt, which is changed daily. This wool garment absorbs the perspiration and does not produce the cold and wet sensations that cotton or silk garments do.

ESSENTIAL HYPERTENSION

In our surgical attack on essential hypertension I have employed two somewhat different but extensive forms of sympathectomy. The rationale of such operations^{7, 23, 47, 49} is to remove the vasomotor control from a large vascular bed, thus creating a reservoir in the denervated vessels when the nonsympathectomized vessels go into spasm²⁰ likewise support the theory of central control. The suprarenal gland is likewise thoroughly denervated, since its innervation is interrupted at its source. The one operation consists of bilateral ventral root rhizotomy,⁴⁵ from the sixth thoracic to the second lumbar vertebrae, inclusive. The operation has been effective in controlling and in relieving the symptoms of essential hypertension in younger individuals in whom there has been no permanent damage to the cardiovascular-renal systems. This procedure is distinctly a major operation and one that does not allow exploration of the suprarenal glands. I have therefore devised a second operation, which is as effective as the first and also permits exploration and resection of the suprarenal glands. The operation is divided into

two stages, and there are two separate incisions. It consists of sub-diaphragmatic, retroperitoneal exposure and resection of all splanchnic trunks as they perforate the diaphragm to enter the abdominal cavity, and removal of the first and second lumbar sympathetic ganglions to interrupt thoroughly the last two white rami of the thoracolumbar out-flow and to permit exploration or resection of the suprarenal gland.²⁵ At this later operation all sympathetic rami below the diaphragm are sectioned except for an occasional fiber that follows the aorta through the diaphragm. It permits thorough denervation of the suprarenal gland by sectioning the rami at their source before entering the capsule.

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sacral center of the spinal cord or fibers making up the parasympathetic nervous system, support the theory that a central mechanism controls and coordinates the antagonistic forces of retention and evacuation of urinary and fecal contents. The sympathetic nervous system supplies the inhibitory stimuli of retention by inhibiting the detrusor muscle of the bladder^{27, 41} and the musculature of the descending colon and rectum and by supplying motor stimuli of contraction to the internal sphincters of the bladder and rectum. The parasympathetic system, through the second, third, and fourth visceral sacral nerves, supplies the reciprocal antagonistic innervation, that of motor contraction of the detrusor muscle and musculature of the lower descending colon and rectum with inhibitory stimuli to the internal sphincters of the bladder and rectum. The sympathetic fibers further innervate the lower portion of the ureters and sphincters and smooth musculature of the mechanism of ejaculation in males in the urogenital trigone.

Musculature imbalances should result from both increased or decreased stimuli of either nervous system. The fault therefore might be due to one of two causes: first, because the stimuli of retention overpowered those of evacuation, and second, because stimuli of evacuation were fewer and of less force than those of retention. Congenital megacolon apparently results from excessive stimuli through the sympathetic nervous system rather than to diminished stimuli in the parasympathetic system, for the symptoms of excessive fecal retention can be controlled and relieved by properly planned sympathetic operations which reduce the number of incoming stimuli. We have observed that the operations which have proved most effective in the treatment of Hirschsprung's disease are not the small, limited types of sympathectomy but are those that include most or all the fibers to the lower portion of the descending colon and sphincter of the anus. Such procedures may vary from bilateral lumbar sympathectomy, including the second, third, and fourth lumbar ganglions, or presacral nerve resection⁸ with division of the inferior mesenteric nerves, to a combination of bilateral lumbar sympathectomy with presacral resection as performed by me, or a combination of bilateral lumbar sympathectomy with presacral neurectomy and division of the sympathetic fibers accompanying the inferior mesenteric artery, as employed by Craig and me.

Myelodysplasia of the sacral cord, traumatic myelitis of the lower thoracic or sacral cord, spina bifida occulta, and intraspinal tumors in the same area can readily impair the parasympathetic spinal center or the fiber tracts carrying parasympathetic impulses. When this occurs, it is apparent that the evacuating force of both urinary and fecal functions will be reduced or be overpowered by what may be a normal retaining force. It is, therefore, in such cases that the surgeon attempts to reduce stimuli by sectioning sympathetic pathways that carry impulses of retention, in order that the weakened force of evacuation will be able to

reciprocate with that of retention. Excessive parasympathetic stimuli or decreased sympathetic stimuli should produce the opposite effects of Hirschsprung's disease and cord bladder. Clinical investigations, however, have not verified these facts, nor have the surgeons contributed definite evidence in the treatment of chronic noninfectious diarrheas or spastic colitis.

I believe that all these observations support the theory that autonomic dysfunctions may be initiated in the cerebral centers, and that pathologic stimuli are transmitted over tracts, ganglions, and rami to the visceral organs and somatic segments.

One could go on at length discussing the factors responsible for the numerous and individual diseases. I believe, however, the recorded observations justify the surgeon to employ properly planned sympathetomies in selected cases for the purpose of removing excessive autonomic stimuli in order to balance reciprocal involuntary functions.

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internal mammary vessels and in the axilla. Irradiation given in this manner is certainly more effective than where the filtration effects of skin have to be surmounted.

We have had no cases of pneumonitis resulting from this method of radium irradiation.

We have not been able to demonstrate that there is any interference with wound healing.

We feel that the very occasional occurrence of swelling of the arm following such radical operations and irradiation is due to a low grade infection in the axilla preventing the redevelopment of lymphatics, rather than in any way connected with the irradiation. In fact, our percentage of such occurrences is less than before we started irradiation.

The free and early use of the arm has contributed much to the comfort of the patient, and, perhaps, by muscular contraction has stimulated regeneration of the lymphatics.

The postoperative irradiation is started in about ten days, and great care is taken to be certain that the radiologist realizes the danger inherent to the employment of the high voltage machines now in use. I am confident that with the advent of so many high voltage machines, there will probably be an increase in the percentage of cases of extensive burns and pneumonitis. Surgeons should cooperate with the radiologists in trying to prevent such a situation from occurring.

If the patient has not passed the menopause, sterilization is done by irradiation of the pelvis. If there is any doubt concerning the propriety of this procedure, one can be convinced easily by a visit to the Memorial Hospital in New York. There he will see roentgenograms of two cases with the thorax filled with metastases (or something that looks like such) following cases of carcinoma of the breast. In these two cases, these shadows in the lungs have disappeared after irradiation of the ovaries. For some years we have noticed an apparent decrease in the size of inoperable cancers in the breast after irradiating metastatic involvements in the pelvis, and perhaps this is the result of some action of the x-rays on the ovaries, with the subsequent development of defensive hormones.

There is a very hopeful field of investigation in the prophylaxis of cancer of the breast by the proper correction of pelvic disorders and effective support of the breast, as well as a study of the hormones. A consideration of such fields leads beyond the scope of this editorial.

We have never seen a case of a true metastasis "cured" by irradiation. We have all seen many cases, however, in which the pain has been greatly relieved by irradiation.

I think we can correctly conclude that there is no conflict between irradiation and surgery. Further, that the chief hope of a cure of can-

Editorials

Irradiation and Surgery in Treatment of Cancer of the Breast

THERE are many controversial questions concerning the relative importance of irradiation and of surgery in the treatment of cancer of the breast. However, one fact seems to be definitely determined, after years of discussion, and that is that no form of irradiation has a replacement value to surgery except as a palliative measure in the hopelessly inoperable cases and for the treatment of local recurrences.

Irradiation has also very definitely demonstrated that by its employment, local recurrences have been markedly reduced. However, this reduction in the percentage of local recurrences is no excuse for dereliction on the part of the surgeon in not performing as complete and as radical eradication of the malignancy as it is possible to do by a "block dissection" carried as far as anatomic limitations will permit. The preoperative employment of irradiation is, perhaps, of greater value than postoperative irradiation. However, preoperative irradiation carries with it certain dangers, one of which is the failure of the patient to return on a specified date for the operation. Patients sometimes delay their returning because, at first, their local condition has improved. They then further delay their return, still hoping for a continuation of their improvement, but unfortunately, until a time when the cancer has extended beyond the reach of surgery and irradiation. This is, of course, a defect in the "follow-up" system, and not of the preoperative irradiation, but is mentioned as a warning to others not to allow a similar calamity to occur in their practice.

After the proper preoperative irradiation has been completed, an operation of the Halsted type should be done. For many years we have made a practice of washing out the operative field with hot normal saline solution. The solution is just about as hot as the hand can comfortably stand without burning. The field of operation is "flushed out" so as to wash out any small clots of blood or possible malignant cells that might be present. In addition to this, it is conceivable that the heat might kill some cancer cells if any happen to have been "squeezed out" during the dissection. Gentle handling of the breast is essential to prevent such a "squeezing out" accident. Such cancer cells have very little resistance to even a moderately high degree of heat.

Before the flaps of skin are closed, radium element, properly screened, is placed around the field of operation, especially in the region of the

caloric, salt, and fluid needs as before operation. All of the wounds healed without infection or rupture: a tribute to asepsis, the method of suturing, and the physiologic state of the infants' tissues.

Every physician whose infant patient has been operated upon for a gastrointestinal obstruction will realize the significance of a record of eleven such cases. This is not luck, but the result of years of development in pediatrics and surgical care. And, after all, there is nothing excessively difficult in the technic and the principles underlying it. Morton³ has discussed them in detail in a previous article devoted to surgery in infancy and in old age.

The surgeon who operates successfully on sick infants is forced to adhere to a program which is physiologically and surgically nearly perfect. It is not out of place to suggest that the surgeon who operates on adults can use these principles to the great advantage of his patients, particularly those whose margins of safety are narrow, as they are in infancy.

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—Clarence E. Bird, M.D.
Louisville, Ky.

cer of the breast is still dependent on the radical operation, but that irradiation is an added safeguard when administered properly and in intelligent hands.

—*Hugh H. Trout, M.D.*
Roanoke, Va.

Congenital Obstruction of the Small Intestine

ONLY a few years ago, pediatricians and surgeons expressed little hope of a successful outcome in any except isolated cases of congenital intestinal obstruction, but recently evidences of improvement in the management of acutely ill infants have multiplied, and it seems established that the mortality rate in these small patients need be very little greater than in older children and adults if the proper precautions are taken.

The transition from the older pessimism to the newer optimism is encompassed in a report by Ladd¹ on the cases of congenital obstruction of the small intestine which occurred in the Children's Hospital in Boston over a period of years up to 1933. Up to the time of Ladd's article there were only twenty-nine cases reported—from a literature replete with autopsy descriptions and operative failures—in which recovery had occurred following operations for malrotation, atresia, or stenosis of the small bowel in infants and children up to the age of twelve years. In Ladd's series there were sixty cases with seventeen survivals.

No more eloquent evidence of this advance in pediatric and surgical technique has been forthcoming than the recent report by Morton and Jones² of eleven consecutive successful operations on newborn infants with congenital obstruction of the duodenum or jejunum.

The babies all had anomalies which, from the day of birth, upset their caloric, water, and salt balance in various degrees. The pediatricians were alert. The early vomiting of congenital obstruction was distinguished from that of pyloric stenosis, which almost always comes on after a normal period of two weeks or more. The necessity for surgical intervention was recognized promptly. By judicious use of roentgenographic studies with barium, accurate diagnoses were made, and by intelligent administration of blood, dextrose and other fluids, the infants were brought to a near physiologic normal and were ready for operation. The technique used would have delighted Halsted. Unhurried gentleness (made possible by skillfully administered ether anesthesia, just heavy enough to allow relaxation), retention of body heat, careful hemostasis, and anatomic suturing of intestinal and abdominal layers with fine interrupted silk brought the babies from the operating table in a condition nearly as good as at the start of the procedures. Feedings were begun almost immediately and care was taken to provide for

caloric, salt, and fluid needs as before operation. All of the wounds healed without infection or rupture: a tribute to asepsis, the method of suturing, and the physiologic state of the infants' tissues.

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The surgeon who operates successfully on sick infants is forced to adhere to a program which is physiologically and surgically nearly perfect. It is not out of place to suggest that the surgeon who operates on adults can use these principles to the great advantage of his patients, particularly those whose margins of safety are narrow, as they are in infancy.

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Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

RECENT ADVANCES IN SURGERY FROM A BACTERIOLOGIC VIEWPOINT

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AIR-BORNE CONTAMINATION OF OPERATIVE WOUNDS

RECENT years have seen the revival of interest in the air as a source of wound contamination, all but forgotten since the days of Lister. Meleney¹ from a study of the bacterial content in the air of his operating rooms has estimated that between 35,000 and 60,000 bacteria fall upon the sterile operative field during the course of one hour. Similar observations have been made in the operating room by Truesdale,² Davis,³ Hart,⁴ Gudin,⁵ Hunt,⁶ and Brewer.⁷ White⁸ has found the hemolytic streptococci abundantly present in the air of rooms occupied by patients with streptococcus puerperal sepsis, and Cruickshank⁹ has found the same organisms present in the air about patients with burns infected with the streptococcus. Meleney and Stevens¹⁰ traced an epidemic of wound infections with the hemolytic streptococci to the noses and throats of the operating room personnel. Hart⁴ demonstrated that the incidence of postoperative wound infections with the hemolytic *Staphylococcus aureus* was seasonal and varied according to the presence of these organisms in the air of the operating room and in the noses and throats of the operating room personnel.

Adequate masking, eliminating currents of air, frequent mopping of operating room walls and floor, elimination of overhead fixtures which may trap dust, complete change of street apparel before entering the operating room suite, and employment of canopies² to cover instrument tables have been advocated to prevent air-borne contamination of the operative field.

The ineffectiveness of the ordinary surgical mask has been demonstrated by Walker,¹¹ Blatt and Dale,¹² and Waters¹³ and has led to the incorporation of an impervious material (cellophane) into the mask to increase its effectiveness.^{12, 13} Walker¹⁴ states that an analysis of sixty masks submitted from hospitals throughout the United States showed none to be effective under all conditions for which a mask might be called into service and concluded that the ideal surgical mask has not yet been perfected.

Sterilization of the air in the operating room has been attempted as the most logical solution to the problem of air-borne wound contamination by Gudin⁵ in Rio de Janeiro and Hart⁴ in this country.

Gudin⁵ has attempted sterilization of the air in the operating room with formaldehyde. The operating room is sealed, and formaldehyde is blown into the room. The formaldehyde is then neutralized with ammonia. Finally, the air is filtered through a solution of tartaric acid which removes the product of the combination of formaldehyde and ammonia (urotropin) and the excess ammonia. Surgeon and patient pass through two or three air-tight sterilized compartments before entering the operating room. In their hands, a noteworthy diminution of infection in clean operative wounds was noted. Theoretically, it would appear that the method, though laborious, would be effective in the presence of adequate masking of the mouth and nose.

In the absence of an ideal surgical mask, Hart turned, in 1934, to the use of radiant energy as the most logical method of continuous sterilization of the air in the operating room. The radiant energy is supplied by a battery of tubes suspended over the operating table producing radiations in the ultraviolet spectrum of the most effective bactericidal wave lengths. Radiation is used constantly before and during the course of the operation. He found that such a battery of radiation destroyed in 60 seconds the hemolytic *Staphylococcus aureus* when lightly sprayed on an agar plate and placed within a radius of five feet of the source of radiation. Agar plates exposed in the unirradiated operating room often picked up as many as 150 bacteria in one hour's time, while plates exposed within 6 to 8 feet of the radiation tubes during operation in the presence of the radiation showed a 95 per cent reduction of this contamination. Working under this radiation it is necessary for the operating room staff to protect their eyes and skin from the effect of the radiations. Clinically, in eighteen thoracoplasties performed under the bactericidal radiation, Hart⁴ found that none of the wounds became infected, that the postoperative temperature elevation was lower and of shorter duration, and that there was less postoperative discomfort in the wound, more rapid wound healing, and quicker return to the preoperative general condition. More recently¹⁵ he has reported a series of 218 cases including herniotomies, thyroidectomies, thoracoplasties, and radical mastectomies with similar results, and concludes that continuous radiation of the operating room represents the only means now at hand to obtain and maintain sterility of the air in the operating room.

TREATMENT OF STAPHYLOCOCCUS INFECTIONS

The demonstration that the staphylococcus produces a hemolytic, leucocidal, and necrotizing exotoxin which is highly antigenic and to which active and passive immunity can be developed in man has revolutionized our concept of staphylococcus infections. During the past six

years, mainly as a result of the work of Parker,¹⁶ Burnet,¹⁷ and Dolman,¹⁸ it has been demonstrated that most strains of staphylococci under appropriate conditions produce active exotoxins. This toxin has been shown to be the cause of the main features of the lesions in all types of staphylococcus infection. From the pooled toxins of various potent strains of staphylococci, an innocuous antigen has been obtained by incubating with formaldehyde. This formalized toxin (staphylococcus toxoid) has proved a valuable antigen for use in active immunization of patients with minor staphylococcus infections and for the production of an antitoxic serum for patients with severe infections, notably those in which a staphylococcus bacteremia is present.

Staphylococcus toxoid has been used to induce active immunization in minor staphylococcus infections by numerous authors.¹⁹ Recurrent furunculosis, chronic osteomyelitis, acne vulgaris, staphylococcus infections of nose, throat, and sinuses, recurrent abscesses, carbuncles, recurrent styes, staphylococcal pyelonephritis, blepharitis, and pyelitis represent some of the conditions for which it has been used. Three reports are unfavorable^{19 b, f, and m} and are explained by Dolman²⁰ on the lack of specificity and potency of the strains of staphylococcus used in preparing toxoid by these authors. All of the other reports are favorable. The best results have been obtained in the treatment of recurrent furunculosis and the least favorable in acne. In all cases, the antitoxic titer of the patient's serum rose during the course of treatment, occasionally as high as twenty times the original level.^{19 *}

The duration of immunity thus produced is not known. In Dolman's series of eighty-one cases treated for furunculosis, only three had recurrences within two years; and in all of these, the antitoxic titer had by this time fallen to its previous level. He showed that the antitoxic titer of patients with recurring furunculosis before treatment is started is usually within normal limits. Thus, no marked increase in circulating antitoxin appears as a rule to be provoked by a series of boils. This he found characteristic of all superficial infections and was in contrast to the response of deep-seated infections, notably chronic osteomyelitis, where the antitoxic titer was uniformly high. In the latter, however, a five- or tenfold increase in the antitoxic titer could usually be induced by injections of staphylococcus toxoid and was followed by favorable clinical results: the general health improved; sinuses occasionally closed; and appetite and sense of well-being improved.

Smith²¹ has recently introduced the theory of hypersensitivity to the staphylococcus toxin as being an important factor in staphylococcus infections. In certain patients, he finds hypersensitivity to skin doses of staphylococcus toxoid in dilutions as high as 1:100,000 and feels that this hypersensitivity is responsible in a large measure for the clinical evidence of staphylococcus infection. In such patients, he desensitizes as well as actively immunizes by injecting subcutaneously gradually in-

creasing doses of toxoid beginning at the highest dilution to which the patient is sensitive and carrying him through the strongest dilution. For routine skin testing a dilution of 1-100 is employed.

For the treatment of severe staphylococcus infections with or without a demonstrable bacteremia, staphylococcus antitoxin has been prepared from the serum of hyperimmunized horses and used with encouraging results by Dolman,²² Gross,²³ Panton, Valentine, and Dix,²⁴ Parish and Clark,²⁵ and Joyner and Smith.²⁶

Dolman,²² working with a staphylococcus antitoxin prepared by the Connaught Laboratories at the University of Toronto, has had the largest experience with the treatment of severe staphylococcus infections with antitoxin. In a series of 104 patients so treated, 24 with various types of staphylococcus infection of skin and subcutaneous tissues all made remarkably rapid recoveries after the administration of antitoxin. In 32 severe cases of staphylococcemia secondary to osteomyelitis in children, 22 recovered. Of 22 apparently hopeless cases of staphylococcemia in adults, five recovered. He concluded that the antitoxin offered the most hopeful and reasonable type of specific treatment at present available for acute staphylococcus infections and toxemias. Gross²³ states that the use of antitoxic serum is of prime importance in staphylococcus septicemia as well as in severe cases of osteomyelitis, furuncles, and carbuncles where symptoms of toxemia are marked. Panton, Valentine, and Dix²⁴ report 13 cases treated with antitoxin prepared by the Lister Institute. In 5 cases of carbuncle, the results were indefinite. In 3 cases of fulminating septicemia, the use of serum did not influence the course of the disease. In 5 cases of pyemia, a general improvement and cessation of further metastatic abscesses followed administration of the serum. Parish and Clark²⁵ allude briefly to the clinical usefulness of antitoxic serum, stating that results were encouraging in all cases.

Joyner and Smith²⁶ have reported the only series of cases treated with staphylococcus antitoxin in this country. They used a refined and concentrated antitoxin prepared by the Lederle Laboratories and now marketed commercially by this company. In 11 of 13 children with acute osteomyelitis with staphylococcemia, a marked improvement in the general condition, subsidence of clinical evidence of toxemia and recovery followed the administration of staphylococcus antitoxin and prompt surgical drainage of the original focus. They demonstrated that the administration of antitoxin shifted the blood picture in the Schilling hemogram and was attended in all 11 cases by a decrease in the percentage of nonsegmented and an increase in the percentage of segmented polymorphonuclear leucocytes.

All who have worked with the staphylococcus antitoxin emphasize that the employment of the serum presents certain difficulties characteristic of serum therapy in general, in addition to those inherent in the case to be treated. The antitoxin is not directly bactericidal but has

an indirect bactericidal action by neutralizing the circulating toxin and thus removing the inhibition of normal bactericidal activity of the blood. It cannot undo damage already suffered by organs or tissues, but it is able to protect from further damage and also to prevent fresh localizations. Free and adequate drainage of localizations of pus remains essential in every case and serum therapy can be regarded only as an adjunct to the recognized and well-established principles of surgical treatment of staphylococcus infections.

ACTIVE IMMUNIZATION AGAINST TETANUS

Because of numerous examples illustrating the inadequacy of passive immunization against tetanus during the World War and the danger of serum reactions, or of inducing hypersensitivity to horse serum in individuals in whom subsequent serum therapy for other conditions may become necessary, active immunization against tetanus has been attempted and is now being carried out successfully.

In 1925, Ramon^{27, 28} prepared a tetanus toxoid for active immunization against tetanus using the same method of detoxification that he had previously proposed for the diphtheria toxin. Ramon and Zoeller,²⁹ and others³⁰ then injected several hundred subjects with their formalized toxin (toxoid), giving three injections at one-month and two-week intervals. A further injection given one or two years later resulted in a great increase in the antitoxic titer of the serum of these individuals. Their results were confirmed by Sacquépée,³¹ Lincoln and Greenwald,³² and Sneath.³³ Sneath found that after the first series of three injections of tetanus toxoid given at four- and two-week intervals to 29 individuals, significant amounts of antitoxin developed in 28 patients, and in 20, a quantity of antitoxin (0.1 unit or more per cubic centimeter) sufficient to provide effective protection against tetanus had developed. Sneath and Kerslake³⁴ in a study of this group twelve to fifteen months later found that only three still possessed a protective concentration of antitoxin. At this time, a single additional injection was given to 14 of the series, several of whom had not produced a protective amount of antitoxin after the first series of injections. Thirteen of these 14 persons had developed a protective concentration of antitoxin by the seventh day after injection, the average being much higher than at the close of the first series. This protective concentration was maintained in all of the thirteen subjects for at least one month.

These findings confirm those of Ramon and Zoeller and form the basis for the present method of immunization. Three injections of tetanus toxoid are given at intervals of four and two weeks. Thereafter, a single injection of toxoid, instead of the usual prophylactic dose of antitoxin, is given at the time of injury. This last dose quickly raises the immunity to a higher level and protects the patient against infection. There is reason to believe, because of the duration of immunity thus

developed, that in persons frequently injured, a dose of toxoid given annually would probably give ample protection. This procedure is recommended for the immunization of persons engaged in activities which submit them to frequent injuries and is now obligatory for every soldier in the French Army.³⁵

CHEMOTHERAPY OF BACTERIAL DISEASES

Although brilliant results have been obtained in the management of protozoan and spirochetal infections by chemotherapy, the treatment of bacterial infections by drugs has until recent years been uniformly unsuccessful. In 1935, Domagk³⁶ observed the selective chemotherapeutic action in streptococcus sepsis in mice of an azo dye containing sulphonamide. Working with Mietzsch and Klarer, he prepared numerous similar compounds whose effect on streptococcus infections excelled all those previously observed in animal experiments. He injected a virulent strain of hemolytic streptococci of human origin into the peritoneal cavities of twenty-six mice. An hour and a half later, twelve received by stomach tube some of this dye. All of the untreated mice died in three or four days. All of the mice receiving the dye survived. Some of the treated mice received only 0.02 mg. of the drug, an amount 100 times less than the maximum tolerated dose. The drug—the hydrochloride of 4 sulphamido-2, 4-diaminoazobenzol—Domagk named “prontosil.”

Levaditi and Vaisman³⁷ using a similar compound synthesized by Girard obtained somewhat similar though less striking results in the treatment of streptococcus sepsis in mice. Nitti and Bovet,³⁸ and Colebrook and Kenny³⁹ found similar results in the treatment of mice with streptococcus infections of high virulence, although a single oral dose was not sufficient to protect mice inoculated with streptococci of low mouse virulence freshly obtained from human infections.

Clinically, Colebrook and Kenny have reported the best controlled series of cases treated with prontosil, although there are numerous clinical reports in the German literature⁴⁰ unanimously favorable to its use. They treated 38 patients with hemolytic streptococcus puerperal infection with oral and intravenous or intramuscular doses of prontosil. In 16 of these cases, they feel that recovery probably would have resulted with or without prontosil, and no conclusions could be drawn. In 17 cases with severe infections, a prompt clinical improvement and remission of fever followed the first few doses. In 3 of these cases, there was evidence of infection of the general peritoneal cavity, and in 5 others, of a beginning of such spread. In all these patients, such signs quickly disappeared after treatment. Three patients with overwhelming infections died, while in one case, treatment seemed to have no effect and in another, it was thought that the treatment aggravated a pyelitis and was stopped. In the 38 patients with puerperal sepsis treated immedi-

an indirect bactericidal action by neutralizing the circulating toxin and thus removing the inhibition of normal bactericidal activity of the blood. It cannot undo damage already suffered by organs or tissues, but it is able to protect from further damage and also to prevent fresh localizations. Free and adequate drainage of localizations of pus remains essential in every case and serum therapy can be regarded only as an adjunct to the recognized and well-established principles of surgical treatment of staphylococcus infections.

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plus a stimulus to healing, both of which he believes are caused by secondary rays emanating from the petrolatum following irradiation. Lilienthal⁵¹ has had similar results in the treatment of septic wounds and sinuses. Stevens,⁵² and Sears and Black⁵³ have studied the bactericidal properties of irradiated petrolatum and have found them so feeble as to be negligible. The latter authors conclude that any beneficial action which irradiated petrolatum possesses must be attributed to a stimulating effect upon local tissue defense.

The maggot treatment of infected wounds as introduced by Baer,⁵⁴ particularly those in which devitalized and necrotic tissue is abundant, continues popular and effective. The method is, however, cumbersome, time-consuming, and often annoying to the patient. It has led to a study of the bactericidal and therapeutic effect of the secretions of maggots. Simmons⁵⁵ has obtained a potent bactericide from the excreta of maggots which kills various strains of virulent bacteria in broth or saline suspension in 5 to 10 minutes. The active principle is nonviable and is not destroyed by autoclaving or desiccation. It has not been used clinically. Robinson has suggested the use of urea⁵⁶ or allantoin,⁵⁷ each present in the excreta of maggots, for local application in the form of moist compresses to infected wounds. He feels that each substance will produce a general cleansing of the wound, reduce infection, stimulate formation of healthy granulation tissue, and hasten healing. Greenbaum⁵⁸ has had favorable results in the treatment of various types of wounds with allantoin used as a 0.4 per cent solution or as a 2 per cent ointment.

Zinc peroxide has been introduced by Meloney⁵⁹ for local application to wounds infected by the anaerobic group of organisms. He finds this drug particularly effective in producing a sustained highly oxygenated environment which inhibits and then destroys anaerobic organisms in the lesions. In a series of chronic undermining ulcers caused by a hemolytic streptococcus which prefers an anaerobic environment, he found zinc peroxide applied daily as a creamy suspension to be the only effective method of treatment available. He has also applied zinc peroxide locally as an adjunct in the treatment of wounds infected with *Cl. welchii* and *Cl. tetani*.

Azochloramide has been found by Kennedy⁶⁰ to be an effective chlorine-compound substitute for Dakin's solution. In Germany, Linka⁶¹ has introduced "penetrin" as a cellular anesthetic of value in wound treatment, and Schweitzer⁶² has used silver mannite for its stimulating, antisecretory, deodorant and epithelializing effect when applied locally to suppurating wounds.

INFECTIOUS GANGRENE OF SKIN AND SUBCUTANEOUS TISSUE

Since Cullen's⁶³ first description of a progressive postoperative gangrene of the abdominal wall following the drainage of an abdominal

ately preceding the use of prontosil, 10 died, with a mortality of 26.3 per cent. In the next 38 cases treated with prontosil, only 3, or 8 per cent, died.

Although prontosil was originally observed to have a selective activity in streptococcus infections, Horlein⁴¹ reports it to effect cures in rabbits with staphylococcus infections. He has also found it particularly effective in the treatment of infections with the pneumococcus type III. Beneficial effect in other types of bacterial infection has not been demonstrated. Prontosil is not bactericidal in vitro, and its manner of action in the animal body is not understood at present.

TREATMENT OF INFECTED WOUNDS

Search continues for an ideal dressing to encourage healing in infected wounds, burns, and indolent ulcers. However, such fundamental principles as free and adequate drainage, specific treatment directed toward the underlying cause of the ulcer or infection, and a rational regime to improve local tissue resistance remain of first importance in the treatment of these conditions.

Cod liver oil applied locally in the treatment of burns and suppurating wounds has received much recent attention, notably from Loehn⁴² in Germany who was its first proponent. He uses raw cod liver oil or a cod liver oil ointment applied locally to many types of fresh and infected wounds, as well as on fresh and old burns. He feels that cod liver oil inhibits bacterial growth, produces a healthy granulation tissue, stimulates epithelization, and allays pain. The effectiveness of cod liver oil he attributes to the presence of its vitamins and not to its oil. Similar results have been obtained by Steel,⁴³ Tennent,⁴⁴ Tumansky and Yatsevieh,⁴⁵ and Iost and Koehergin,⁴⁶ while Buchheister⁴⁷ combines honey and cod liver oil with equally satisfactory results.

Tumansky and Yatsevieh found that on being placed in cod liver oil the growth of streptococci ceased in one hour and staphylococci in six hours. The addition of petrolatum decreased this bactericidal property. Padula,⁴⁸ observing the effect of the local application of vitamins to wounds in experimental animals, found that vitamin D favored healing in animals on a normal or low vitamin diet, vitamins B and C favored healing only when the animals were on a low vitamin diet, while vitamin A retarded healing in animals on a low vitamin diet and did not affect healing in those with a normal diet. Holtzinger,⁴⁹ studying the effect of vitamins on bacterial growth, found that vitamin D increased the luxuriance, while vitamin A inhibited growth.

Ultraviolet irradiated petrolatum has been used locally in various forms of wounds and infected sinuses. Eising⁵⁰ who proposed its use observed that the bacterial count in the discharge from wounds so treated decreased, growth of granulation tissue was stimulated, and healing hastened. This effect he attributes to a bactericidal action

plus a stimulus to healing, both of which he believes are caused by secondary rays emanating from the petrolatum following irradiation. Lillenthal⁵¹ has had similar results in the treatment of septic wounds and sinuses. Stevens,⁵² and Sears and Black⁵³ have studied the bactericidal properties of irradiated petrolatum and have found them so feeble as to be negligible. The latter authors conclude that any beneficial action which irradiated petrolatum possesses must be attributed to a stimulating effect upon local tissue defense.

The maggot treatment of infected wounds as introduced by Baer,⁵⁴ particularly those in which devitalized and necrotic tissue is abundant, continues popular and effective. The method is, however, cumbersome, time-consuming, and often annoying to the patient. It has led to a study of the bactericidal and therapeutic effect of the secretions of maggots. Simmons⁵⁵ has obtained a potent bactericide from the excreta of maggots which kills various strains of virulent bacteria in broth or saline suspension in 5 to 10 minutes. The active principle is nonviable and is not destroyed by autoclaving or desiccation. It has not been used clinically. Robinson has suggested the use of urea⁵⁶ or allantoin,⁵⁷ each present in the excreta of maggots, for local application in the form of moist compresses to infected wounds. He feels that each substance will produce a general cleansing of the wound, reduce infection, stimulate formation of healthy granulation tissue, and hasten healing. Greenbaum⁵⁸ has had favorable results in the treatment of various types of wounds with allantoin used as a 0.4 per cent solution or as a 2 per cent ointment.

Zinc peroxide has been introduced by McIney⁵⁹ for local application to wounds infected by the anaerobic group of organisms. He finds this drug particularly effective in producing a sustained highly oxygenated environment which inhibits and then destroys anaerobic organisms in the lesions. In a series of chronic undermining ulcers caused by a hemolytic streptococcus which prefers an anaerobic environment, he found zinc peroxide applied daily as a creamy suspension to be the only effective method of treatment available. He has also applied zinc peroxide locally as an adjunct in the treatment of wounds infected with *Cl. welchii* and *Cl. tetani*.

Azochloramide has been found by Kennedy⁶⁰ to be an effective chlorine-compound substitute for Dakin's solution. In Germany, Linka⁶¹ has introduced "penetrin" as a cellular anesthetic of value in wound treatment, and Schweitzer⁶² has used silver mannite for its stimulating, antisecretory, deodorant and epithelializing effect when applied locally to suppurating wounds.

INFECTIOUS GANGRENE OF SKIN AND SUBCUTANEOUS TISSUE

Since Cullen's⁶³ first description of a progressive postoperative gangrene of the abdominal wall following the drainage of an abdominal

abscess, interest has been stimulated in infectious gangrene of the skin and subcutaneous tissues. Stewart-Wallace,⁶⁴ in 1935, collected thirty-seven cases of progressive postoperative gangrene of the skin from the literature. Since then additional cases have been reported by Holman,⁶⁵ Hicken,⁶⁶ Coakley and Klein,⁶⁷ Willard,⁶⁸ and Liedberg.⁶⁹ Melency⁷⁰ has classified the various forms of infectious gangrene of the skin and subcutaneous tissue into acute and chronic groups. Gas gangrene and hemolytic streptococcus gangrene represent the acute forms of the disease, while progressive postoperative synergistic gangrene, gangrenous impetigo or eethyma, amebic gangrene, and fusospirochetal infections represent the chronic forms.

As described by these authors, progressive postoperative gangrene usually follows drainage of an abscess in the thorax or abdomen. The wound becomes painful, its margins dusky and elevated; and between it and the normal surrounding skin, an area of reddening appears. Gradually the process progresses; margins of the ulcer become necrotic, while an advancing zone of dusky cyanosis and another of reddening in the skin precede the advance of the gangrenous process. Huge areas of skin may become involved; Stewart-Wallace's case involved the entire back from occiput to iliac crests, the left flank, left side of the chest, and entire abdomen. In careful bacteriologic studies of his cases, Melency⁷¹ has uniformly found a microaerophilic nonhemolytic streptococcus to be present in the advancing margin of the lesion, while a hemolytic *Staphylococcus aureus* is present in the necrotic zone. By animal inoculation, he has shown that either organism injected alone causes no reaction, while a combination of the two usually produces a gangrenous lesion. His belief that the condition is due to a symbiotic phenomenon involving these two organisms has been widely accepted, although, because of a lack of uniformity of bacteriologic studies, other cases in the literature with one exception⁶⁸ did not show these organisms. In most of the recorded cases, at least two organisms have been found, and many authors have corroborated Melency's observation that two organisms together produce more pronounced lesions than one alone. Regardless of any difference of opinion which may exist in regard to exact etiology, all agree on the futility of conservative measures in the treatment of the condition. A bold, extensive, and thorough excision of the margin of the ulceration, including the outer zone of redness, preferably with the cautery, has almost invariably resulted in a cessation of the process.

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Review of Recent Meetings

REVIEW OF THE SOUTHERN SURGICAL ASSOCIATION MEETING, DECEMBER 15, 16, AND 17, BILOXI, MISS.

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THE annual meeting of the Southern Surgical Association was held December 15, 16, and 17 at the Edgewater Gulf Hotel in Biloxi, Miss. The meetings were extremely well attended, and there were many important contributions. Of a total of forty listed papers, thirty-nine were presented.

Dr. George Heuer, of New York City, discussed *Surgical Aspects of Acute Cholecystitis*. His study included 150 cases from the Cincinnati General Hospital, 800 cases from the records of the old New York Hospital, and 614 cases from the new New York Hospital, a total of 1,565 cases. There is no direct parallelism between the stage of pathology of the inflamed gallbladder and the symptoms which these patients present. His studies showed that gangrene and perforation of the gallbladder occurred in approximately 20 per cent of the cases of acute cholecystitis. The mortality following perforation of the gallbladder averages approximately 46 per cent. He presented a series of 163 consecutive cases of acute cholecystitis in which operation was done early. In this group, 16 had perforation on admission. The mortality for the entire series of 153 cases was 3.2 per cent. Overemphasis has been placed on the danger of operation in the acute stages of cholecystitis, and the mortality is thus shown to be less from immediate than from delayed operation.

Dr. Frank Lahey, Boston: *Strictures of the Common and Hepatic Duct*. The most common cause of stricture is operative trauma, and probably the most common cause of injurious trauma at operation results from attempts to control bleeding from the cystic artery. Lahey described nine different types of reconstructive procedures which they have successfully employed for these strictures. The production of complete external biliary fistulas with later transplantation into the duodenum, stomach, or jejunum is not a satisfactory procedure. The Heineke-Mikulicz type of reconstruction, splitting the stricture longitudinally and suturing it transversely, is not applicable for long strictures. He uses a T-tube inserted into the reconstructed duct through a separate opening above the site of repair. In these instances, the lower end of which passes down the duct through the site of repair. End-to-end anastomosis after the resection of a stricture should not have tension on the suture line, otherwise the lines of suture will give way. In some instances, he advises anastomosis of the obstructed duct to the duodenum or to the stomach. In rare instances, it is advisable to leave a T-tube in permanently.

Dr. Waltman Walters, Rochester, Minn., in discussing Dr. Lahey's paper, said that the end-results of a number of strictures (29) which he had reported before the Society in 1931 showed that approximately 50 per cent have remained permanently well.

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Dr. Frederick Collier, University of Michigan: Treatment of Typhoid Carriers by Cholecystectomy. He finds that 2 to 3 per cent of all typhoid cases become carriers; that is, they have persistent positive stools and positive bile cultures for a minimum of a year after the attack of typhoid. Collier performed cholecystectomies in such carriers which could not be cured otherwise. Ninety per cent of these were cured. The pathology of the removed gallbladder is usually that of chronic cholecystitis, but occasionally there is acute cholecystitis with intramural abscesses.

Dr. John deJ. Pemberton, Rochester, Minn.: Regional Ileitis. In a series of 39 cases examined at the Mayo Clinic and studied by Dr. Pemberton and Dr. P. W. Brown, the lesion was most frequently single but was occasionally multiple. It occurred usually in the terminal ileum but occasionally involved other segments of the intestinal tract. Changes in the small intestine which could be detected roentgenologically occurred early in the course of the disease. Clinically the cases present the following symptoms: frequently pain, sometimes with nausea, vomiting, and abdominal distention; occasionally diarrhea, loss of weight, anemia, and fever. The etiology is not known. The treatment of choice is a two-stage operation, the preliminary operation consisting of an ileocolostomy, subsequently resection of the diseased segment or segments. Of 9 cases of extensive regional enteritis, resection was performed in 2 and the patients have remained well for one year and for eight months, respectively. In the remainder of these cases, only the short-circuiting operation was performed, and the results have not been encouraging. Of the 27 cases in which the process was localized, in 19 the patients are well; 4 are still having trouble; 3 have died; and 1 has not been traced. In 8 of the 27 cases, a short-circuiting operation was the only operative procedure employed. In 3 cases in which only the short-circuiting operation was performed, a deficiency syndrome developed.

Dr. W. L. Estes, Jr., Bethlehem, Pa.: Enteritis of the Obstructed Loop After Entero-anastomosis for Intestinal Obstruction. Estes called attention to the fact that if a blind loop is left after an entero-anastomosis around obstructed lesions, the patient will develop signs of enteritis or enterocolitis. The treatment is resection of the blind loop. The condition is much more apt to occur when the blind segment is distal to the point of anastomosis and less likely to result when the blind segment is proximal to the point of anastomosis.

Dr. William Perrin Nicolson, Jr., Atlanta, Ga., described a controllable cecostomy in which a mushroom catheter was placed into the cecum and a rubber guard like that of a Brauer tube placed over the tube externally, so that the cecal and abdominal walls were compressed between the two flanges. The tube is clamped when the patient is ambulatory, and no leakage occurs.

Dr. J. L. McGehee, Memphis, Tenn.: Chronic Dilatation and Obstruction of the Duodenum. Dr. McGehee reported a case of a female, aged eighteen years, who had severe vomiting spells for six weeks. Roentgenography showed obstruction of the terminal end of the duodenum. At operation there was a constriction at the terminal portion of the duodenum (congenital) which was due to pressure by the superior mesenteric artery and the middle colic artery on the duodenum. Duodenojejunostomy and colopexy to correct the drag were followed by cure.

Dr. Willis D. Gatch, Indianapolis, described a new method for closing a perforated ulcer on the anterior surface of the duodenum or pylorus. It consists of overlapping the proximal portion of a normal stomach for a distance of several centimeters over the ulcer onto the duodenum distal to the ulcer. In all, there were 26 cases, all men, with 5 deaths (19.6 per cent mortality). None of the 18 cases

operated upon within eleven hours of the perforation died. The mortality varied directly with the length of time elapsed after the perforation. Follow-up studies on these cases showed no disturbance in physiology and no obstruction to the outlet of the stomach.

Dr. Donald C. Balfour, Rochester, Minn.: *Factors of Significance in the Prognosis of Cancer.* Balfour summarized some of his experiences with cancer of the stomach which are significant in the prognosis. In a statistical study of over 2,100 cases of operations for gastric carcinoma, the following facts were obtained: The shorter the history, the less chance of cure; and the larger the tumor, the better the prognosis. A lesion at the pyloric end of the stomach was less amenable to cure than lesions of the body and fundus. There was less chance of permanent cure in cases with lymph node involvement, but after five years, patients with and those without lymph nodes involvement had practically the same chance of continued existence. Broder's grading showed a definite difference in the life expectancy, the Grade 4 types dying relatively much earlier than those of Grades 3, 2, and 1, respectively. The higher the gastric acidity, the better the prognosis. Forty-five per cent of cases are operable, but only 19 per cent of the cases are amenable to some type of operation (resection) which could possibly promise a cure. About 30 per cent of cases that have had extirpation of the growth and regional nodes will have five-year cures. Average life expectancy without palliative or radical operation is five months and with palliative operation (gastroenterostomy) is six months.

Dr. John C. Caulk, St. Louis. Caulk divided tumors of the renal pelvis and ureter into two pathologic types which have two entirely different clinical appearances. The papillary type comprises 80 per cent of the tumors and the squamous type, 20 per cent. The papillary type has a tendency to involve the respective ureter and does so in 50 per cent of the cases. They are multiple, slow-growing, and do not have distant metastasis. In this type it is important to remove the entire ureter, including the intramural portion in the bladder. If this is not done, 86 per cent will show recurrence. The squamous type of tumor metastasizes to distant regions but does not have a tendency to invade the ureter. Therefore, when the tumor is recognized as being squamous, it is not necessary to remove the ureter.

There were three papers on appendicitis. In general, it was emphasized that there are far too many deaths in the United States from appendicitis each year, that the mortality is still too high, that it is due to lack of education on the part of people and doctors.

Dr. Roy D. McClure, Detroit, reported a detailed study of 252 consecutive cases of acute perforated appendicitis with peritonitis. The mortality was increased with cathartics and with complications present on admission. McClure emphasized the fact that 60 per cent of the patients had symptoms that were atypical of appendicitis but not signs which were atypical. Generally the objective findings are typical. He does not use the conservative treatment in cases that have developed complications. The mortality in his series was greater the closer the incision approached the midline. He favors the McBurney incision in acute appendicitis.

The majority of the discussers approved of the use of the McBurney incision in acute appendicitis and decried the use of right rectus incisions.

Dr. George H. Bunch and Dr. Roger Doughty, Columbia, S. C.: *Principles and Results in the Treatment of Acute Appendicitis.* The authors emphasize the technic of operation and the management of the case as the important factors in the mortality of appendicitis. They favor the expectant treatment in those cases which have developed complications, such as perforation with abscess, peritonitis,

etc. They emphasize that the greatest mortality occurs on the third, fourth, fifth, and sixth days of the disease and state that this is directional in its significance, i.e., to delay operative intervention during these periods. Bunch's mortality was, for unruptured group, 0.25 per cent; for ruptured group, 9.9 per cent; total mortality, 2.4 per cent. South Carolina has the lowest mortality of any state or any section of the United States. The reason, they believe, is due to Le Grand Guerry's teachings of the delayed operation in those cases of acute appendicitis which have developed complications from perforation.

Dr. E. P. Hogan, Birmingham, Ala., discussed the appendix problem by analyzing the mortality from various hospitals in Birmingham. They were variable, but the general trend was that in more recent years the mortality is becoming less. Hogan believed that the proper way of attacking the appendicitis problem was the education of the doctors and the public at large; he suggested that students should be taught in school what appendicitis is and the dangers of delay and neglect.

Dr. Deryl Hart, Durham, N. C., reported the results of his clinical and experimental investigations on the sterilization of the air in the operating room with radiant energy. By culturing the air in the room, he found a high degree of contamination. Reports from other men throughout the country who cultured the air in their operating rooms showed similarly a high degree of air contamination. The number of persons in the operating room increases the amount of contamination. Ultraviolet light at a distance of five feet practically sterilized contaminated agar plates within a period of sixty seconds for light contamination to five minutes for heavy contamination. The experimental evidence presented by Hart was very convincing. Installation of ultraviolet lights over their operating tables has reduced the incidence of unexplained infections following operation from 5.5 per cent to 0.6 per cent. The method necessitates wearing heavy covers for the heads of all the operating team and protection for the eyes.

Dr. Charles C. Green, Houston, Tex., reported an interesting case of local tetanus of the right arm occurring twelve days after injury. He cites this as an instance supportive of the view of Abel and his colleagues who believe that tetanus is not due to action of the toxin on the nerve or on the central nervous system, but due to direct action on the muscle itself.

Dr. W. M. Firor, Baltimore, in discussing Green's paper, cited some very important experimental work that has been done by Abel and himself. After injection of toxin directly into the central nervous system, hyperexcitability of the peripheral musculature but no increase in tone resulted. On the other hand, direct injection into the muscle caused stiffness and rigidity. They believe that the stiffness and rigidity is due to the local reaction on muscle, and that the hyperexcitability is due to the effect on the central nervous system.

Dr. Mont R. Reid, Cincinnati, discussed wound healing and emphasized careful operative technique and its relation to the healing of wounds. He stressed that living tissue has resistance to infection but that ischemia, strangulation, or hemorrhage in the wound enhances the growth of organisms. Antiseptics interfere with healing and injure the wound more than the contaminating organisms.

Dr. Edwin P. Lehman, University of Virginia, analyzed the postoperative record of the cases having had spinal anesthesia. Spinal anesthesia at the University of Virginia has been the method of choice for those operations below the diaphragm in which contraindications are not present. The results in 450 cases of spinal anesthesia and 450 cases of general anesthesia were compared. The cases selected for comparison were those in which postoperative complications would not be ex-

pected, such as herniorrhaphies, perineorrhaphy, hysterectomy. The incidence of nausea, distention, headaches, catheterization, backache were all less under spinal than under general anesthesia. Complications were slightly less, the postoperative course smoother under spinal anesthesia. The mortality for spinal anesthesia was 0.028 per cent. There was no end of proselytes convinced or becoming convinced that spinal anesthesia is a method which is safe and which has many advantages over the general.

In discussing this paper, Dr. Hubert Royster, Raleigh, N. C., brought the discussion to an anti climax by asking for a vote by the surgeons expressing preference for spinal anesthesia or general anesthesia on themselves. The ones who preferred general anesthesia were very much in the majority.

In discussing this paper, Dr. Lahey made a plea for the education of anesthetists in the medical school, saying that most of the untoward results were due to unintelligent management or administration of spinal anesthesia.

Dr. Donald Guthrie, Sayre, Pa., discussed avertin anesthesia, reporting a death which was due to respiratory failure and reporting statistics and impressions that he had gained from communications with other surgeons. The consensus of opinion was that avertin anesthesia is a valuable adjunct to anesthesia, though many men will not use it, and others are suspicious of its untoward results.

Dr. Rudolph Matas, New Orleans, after receiving the standing respect of the members, reported a most interesting case of envenous angioma of the arm with regional recurrence and distant metastases. The patient at birth had an angioma on the finger of the hand. In fifteen years because of the progress of the lesion upward, he had an amputation in the middle of the forearm. When the patient was twenty-one years of age or six years after the amputation of the forearm, there was noted an angioma in the stump; at this time the systemic and local symptoms of arteriovenous fistula were apparent. At the age of twenty-one years, the arm was disarticulated at the shoulder and ten years later the patient had evidence of another recurrence in the chest wall in the region of the amputated stump and also at some distance below on the chest wall. There was a sponge-like angiomatous lesion that permitted direct passage of blood from arteries to veins. The patient had an enlarged heart and signs of cardiac weakness on exertion. All local signs of an arteriovenous communication were present.

Dr. Arthur M. Shipley and Dr. Nathan Winslow, Baltimore: **Extracranial Aneurysm of the Internal Carotid: Report of Two Additional Cases and Review of the Literature.** Many of these cases have been discovered accidentally by the surgeon opening the protrusion into the pharynx, thinking it was a peritonsillar abscess. Occasionally such lesions have ruptured spontaneously into the pharynx. It is important to be cognizant of the lesion. Whereas the lesion is extremely rare, Shipley and Winslow emphasize the dangers of the incorrect diagnosis. The operation of choice is ligation of the internal carotid artery; they advise preliminary approach under local anesthesia and temporary ligation to test the collateral circulation by noting any evidence of dizziness or other symptoms that might indicate an impending cerebral accident. If the patient weathers the preliminary operation, the prognosis is good for permanent cure.

Dr. Foy Roberson, Durham, N. C., in discussing cancer of the female breast, called attention to the fact that the deaths from cancer are 9.9 per hundred thousand population in the United States yearly. In North Carolina, one in 200 deaths is due to carcinoma of the breast. Roberson believes the most important changes which would produce an improvement in the management of cancer would be the delegation of all carcinomas of a certain portion to the care of one man in charity hospitals of small communities where there are relatively a small number of

eases. He believes in this way the community would have an expert in each particular phase of cancer therapy, and that there would be more interest and that the patient would benefit.

Dr. Frank P. Strickler, Louisville, Ky.: *A Satisfactory Method of Repairing Crucial Ligaments.* Strickler believes that not all cases need operation, but only those which do not have a satisfactory result from the conservative treatment, that is, prolonged immobilization. Rupture of the anterior crucial ligament permits anterior dislocation of the tibia on the condyles of the femur in extension, and rupture of the posterior crucial ligament permits posterior dislocation of the articular surface of the tibia from the condyles of the femur with the knee in flexion. Strickler's technic consists of a long lateral incision on the thigh through which he obtains a wide piece of fascia lata which when rolled is as thick as a pencil. This is threaded through a drill hole which goes into the femur above the condyle down into the intercondylar notch, and then through a drill hole which passes from the interarticular superior surface of the tibia anterior to the spine through the tuberosity, emerging laterally. The fascia lata is not secured here, but is carried back to its point of origin and sutured to its other end.

Dr. Charles S. Venable, San Antonio, Tex.: *Experimental Study of the Changes in Bone in the Presence of Metals Based Upon Electrolysis.* Venable reported some very interesting and significant experimental work done by himself, Walter G. Stuck, and Asa Beach, the object of which was to determine the causes of the changes in bones in the presence of metals. He showed definite osteoporosis occurring in those instances in which there were two metals, even if they were in one foreign body, such as one screw, which permitted electrolysis from one metal to another. In instances in which osteoporosis was occurring, they obtained by chemical analysis copper, zinc, chromium, or iron, etc., in the region around the foreign material and also in distant organs such as the liver. This was interpreted as being significant of the fact that electrolysis made the migration of ions from one metal to another. They concluded that such electrolysis produced absorption around the screws or osteoporosis, because in material which had no ions in the surrounding tissue or in distant organs, e.g., in vitallium, which does not contain iron, there was no tissue reaction and there was no evidence of osteoporosis. They believe that this explains the osteoporosis that occurs from foreign bodies and they submit a formula for a metal which would result in a minimum reaction.

Dr. Willis C. Campbell, Memphis, Tenn., stated that he had 495 cases of fractures of the neck of the femur, of which 214 (43 per cent) were complete intracapsular fractures, 229 were intratrochanteric, and 52 were impacted fractures. Internal fixation is not new, but the advent of lateral as well as anteroposterior x-rays has made it feasible to be sure reduction has been accomplished, and he believes that this with internal fixation is responsible not only for a more comfortable convalescence, but also for higher percentages of union. In 19 cases in which this method was used by him on intracapsular fractures of the neck of the femur and which have been followed for a sufficient length of time, all have shown bony union.

Dr. Urban Maes, New Orleans, previously reported a mortality rate of 7.6 per cent in 341 thyroidectomies at Charity Hospital. In the last two years, there have been 321 thyroidectomies with a mortality of 3.7 per cent. There is a high mortality in the negro race, 12 per cent. Fifty-four men operated upon these 662 cases. Some of their cases were studied for liver function with the hippuric acid test, and it was found to be an index of the risk of the operation. In severe cases, the liver function is low, and it is possible to follow quite closely the clinical improvement in the patient before operation with this test.

Dr. Earle Drennen, Birmingham, Ala., analyzed 300 consecutive cases of thyroidectomy which he himself had done. He claimed nothing original, but showed an extremely low mortality of 1 death in the 300 cases, one-third of one per cent. These favorable results Dr. Drennen attributed to detailed study of the cases and careful preparation of the patients before operation.

Dr. Willard H. Parsons, Vicksburg, Miss.: Treatment of Heart Disease by Total Ablation of the Normal Thyroid. Drs. Parsons and Purks sent out a total of 677 questionnaires, and 342 replies were obtained relative to the treatment of heart disease by the total ablation of the normal thyroid. Of those who replied, 59 had had definite experience with the operation. The results in these cases and 4 of Dr. Parson's own were analyzed. In 229 cases of congestive heart failure represented, there was an operative mortality of 10.48 per cent. The results were excellent in 34.6 per cent, and satisfactory improvement was obtained in approximately 60 per cent. In angina pectoris, the results were even better. In 133 cases, the mortality was 3.75 per cent; the excellent results were obtained in 55.46 per cent; and moderate improvement occurred in 28.12 per cent. He believes that the status at present is that good or satisfactory improvement occurs from thyroidectomy in angina pectoris in 80 to 90 per cent of the cases.

Dr. Lon Grove, Atlanta, Ga.: Fibroangioma of the Spleen. Dr. Grove reported a case of a four-month-old infant who was normal at birth but who subsequently developed a lump in the left upper quadrant of the abdomen. This was removed at operation and a tumor 5 by 5 cm. in diameter was found in the spleen. Microscopically it proved to be a fibroangioma. These tumors are extremely rare.

Dr. Louis Frank, Louisville, Ky., reported a case of hemolytic streptococcal infection of intraabdominal lymph nodes in which suppuration occurred. They have found reported only six similar cases. The patient's initial portal of entry was the foot. The patient was extremely ill. Incision and drainage of an abscess was followed by ultimate recovery. Repeated blood transfusion and x-ray therapy did not seem to arrest the disease in this instance, but an intravenous injection of metaphen was followed by prompt improvement. The duration of the illness was eleven weeks.

Dr. I. M. Gage, New Orleans, in discussing Dr. Frank's paper stated that on the Tulane Surgical Service they had had between 25 and 30 cases of streptococcal lymphadenitis. In only 2 cases was *Streptococcus hemolyticus* obtained. Dr. Gage advises preliminary aspiration determining the type of organism and if it is streptococcus, nonintervention treatment until actual suppuration has occurred, in which instance incision and drainage is indicated. He advises strongly against incising and draining before signs of suppuration.

Dr. Albert O. Singleton, Galveston, Tex., reported twenty-eight cases of lymphangioma. They were divided into simple, cavernous, and cystic types. There were 11 cases of the simple type and 17 cavernous or cystic. Dr. Singleton reviewed the embryologic development of the lymphatic system and showed how such congenital cysts could develop. Infection is a frequent cause of death after operation. One particularly interesting case was that of an infant with an extensive congenital lymphangioma of the arm extending up onto the chest and the base of the neck. Operation was done to remove part of the lesion from the base of the neck. One year later, the patient had signs of an infection and died from what was thought to be a pneumonia. Postmortem examination revealed that the tumor had extended into the mediastinum and into the right side of the chest and had become infected.

Dr. K. H. Aynesworth, Waco, Tex., gave a general discussion of medical and surgical lesions above the diaphragm which present symptoms simulating acute surgical lesions in the abdomen. It is important that lesions above the diaphragm produce no abdominal rigidity. If sudden palpation is done, it may cause a reflex rigidity which may give an erroneous impression, but if the type of examination Aynesworth advises is carried out there is no rigidity. He advises gentle, light palpation with the finger, very light, to detect any rigidity followed by gentle, firm, and increasing pressure with the palm of the hand in the region of the pain. In those instances in which the lesion is above the diaphragm, although there may be a slight sense of resistance at first, it disappears when the pressure is continued.

Dr. C. C. Coleman, Richmond, Va., gave a very important paper on the surgical treatment of facial spasm. In discussing this paper, Dr. Joe King, of New York City, said that it was the most informative paper he had heard on this particular subject. Coleman had in the last year five cases of facial spasm of unknown etiology. Three were unilateral and two were bilateral. In unilateral cases, the pathology is in the peripheral nerve; in the bilateral cases, it is in the cerebrum. The character of the spasms is different in the two types. Alcohol injection of the facial nerve is not simple; it paralyzes the entire nerve. He prefers division of the nerve anterior to the ear, preserving the mandibular branch and resuturing the upper fibers. This keeps the mouth balanced. He believes that facial hypoglossal anastomosis after division of the facial nerve will offer perhaps even better possibilities for a permanent cure in this unfortunate condition.

Dr. Ernest Sachs, St. Louis, in order to attack with radiation therapy malignant tumors of the brain and cranial cavity, irradiated cases on the table when the bone flap had been turned and the adjacent skin and skull were protected by lead. In five cases, they gave over 600 roentgen units, and it is now possible by elimination of certain filters to do this in forty minutes. As yet, they have not followed the cases for a sufficient length of time to give the result. They had previously tried the implantation of radium, and the results in these malignant cases were not satisfactory; therefore he was glad to discard it for something which promised better results.

Dr. E. Dunbar Newell, Chattanooga, Tenn., discussed the treatment of brain trauma by the general surgeon. There are approximately 112,000 cerebral injuries in the United States annually, and the mortality possibly averages around 25 per cent. Most of the cases have to be treated, not by neurosurgeons, but by general surgeons. In a previously reported series, they had a mortality rate of 31 per cent. In their present group, it was reduced to 20 per cent. In the last 100 cases, there have been five deaths. Six were operated upon for depressed fractures, two for middle meningeal syndromes. Newell emphasized that the patient should not be changed and molested by moving, but should be put at rest; he cautioned strongly against intervention or needless surgery except where it is absolutely indicated.

Dr. Daniel C. Elkin, Atlanta, Ga., showed a motion picture in colors of suturing a stab wound of the heart. The presentation was striking and illustrated nicely the heart tamponade and its relief by the gush of blood from the pericardium following incising the pericardium. They have had 18 cases, 13 of which have been operated upon by Dr. Elkin. Of the 18, 7 died, 11 recovered.

Dr. Lucius E. Burch and Dr. John C. Burch, Nashville, Tenn.: The Technic of Perineorrhaphy. They presented a paper on a method for the repair of a rectocele. As a preliminary to operation, they infiltrated under the mucosa with adrenalin 1 to 120,000 in $\frac{1}{4}$ per cent novocaine as a hemostatic measure. The

mucosa is removed with scissors. The vaginal fascia is then incised. After reducing the rectocele by a plication, they expose the levators and suture them under the rectocele.

Dr. Hilliard R. Miller, New Orleans: *Echinococcal Disease, With a Report of Primary Echinococcal Cyst of the Uterus.* Dr. Miller reported an interesting case of an echinococcal cyst of the uterus, the first occurring in North America. The patient, a colored woman, evidently obtained infestation by eating clay during pregnancy, which she thought was beneficial. The tumor, the size of a grapefruit, was attached to the uterine wall and was removed by doing a partial fundusctomy. On sectioning the tumor subsequently it proved to be a typical echinococcal cyst. The patient always has lived in Louisiana. There has been no recurrence since the operation.

Dr. John T. Moore, Houston, Tex., called attention to the Shropshire operation. This operation for hysterectomy is done by cutting through the lateral wall of the uterus itself instead of cutting through the broad ligaments. Preliminary to cutting the slab, special clamps are applied to stop bleeding. It is a rapid method of doing a hysterectomy. In closure, the lateral stumps, which consist of part of the wall of the uterus, are sutured together by mattress sutures. This forms a strong protective closure and tightens the uterosacral and uterovesicle ligaments. The same procedure can be used with slight modifications on vaginal hysterectomies.

Dr. Curtis H. Tyrone, New Orleans, reported 206 cases of vaginal hysterectomies which he had done personally between August, 1931, and November, 1936. These cases were done in instances in which such an operation was one of choice for the particular pathology, that is, in cases in which the cervix was diseased and in which there was a prolapse. The operation is not indicated in all cases, but one should be able to do a hysterectomy either by the vaginal or by the abdominal route. In his series of 206 cases, he had the extremely laudable mortality rate of less than 0.5 per cent, 1 death. There was complete relief of symptoms in all cases except one. Preoperatively, 204 of the cases had leucorrhea and 205 had backache.

Book Reviews

A Textbook of Surgery. By American Authors, edited by Frederick Christopher. Cloth. Pp. 1608, with 1349 illustrations. Philadelphia, 1936, W. B. Saunders Company. \$10.00.

This new textbook of surgery is distinctive in that it is not the work of a single individual or of a small group of men, but the product of the combined labors of some 180 contributors, each eminently qualified to discuss the topic assigned to him. The research training, bibliographic knowledge, and wide experience of the individual authors leave their imprint upon the pages of the book.

The general outline is much like that of other textbooks of surgery, although in some respects there are departures from the traditional pattern. The early chapters deal with inflammation and bacteriology, but the discussion of aseptic surgical technique is found near the end of the book linked with some excellent chapters on minor surgical procedures, anesthesia preoperative and postoperative care. Diseases of the thyroid gland and of the islands of Langerhans are discussed under the heading "The Endocrine System" rather than in the sections devoted to the neck and the pancreas.

The text embraces the broad field of the general surgeon and includes special chapters devoted to orthopedic surgery, plastic surgery, and gynecology. Roentgenology, diagnostic and therapeutic, is given space commensurate with its importance in surgical practice, an entire chapter being devoted to this subject.

No very rigid outline has been followed in the writing of the different sections, but there is the usual division of material under descriptive headings such as: definition, etiology, symptoms, diagnosis, prognosis, and treatment. There are only occasional brief references to the history of surgery. Some authors more than others have stressed the fundamental sciences upon which surgery is based. The lack of uniformity in this respect is not due necessarily to the varying points of view of the different contributors, but is due largely to the nature of the subject requiring elucidations. For example, in describing the treatment of fractures, frequent references to anatomic facts are found to be helpful; and in the section on diseases of the thyroid gland, fundamental data concerning not only gross and microscopic anatomy but embryology, physiology, and chemistry are included. The importance of bacteriologic data is not always stressed sufficiently, but there are sections in which bacteriology has been given adequate consideration, as in the case of acute empyema. Perhaps it is sufficient that an early chapter deals with the relationship of bacteriology to surgery.

The discussion of the many aspects of clinical surgery in this book includes references to some of the newer principles and methods of treatment. In the section on fractures are to be found the modern methods of skeletal traction, "well-leg traction," and a description of operative procedure in fractures of the femoral neck. The discussion of diseases of the ductless glands has been brought up to date. The chapter on "Cancer of the Breast" includes an able discussion of radiotherapy. The use of suction siphonage through the duodenal tube in intestinal obstruction is described and the chapter on "Orthopedics" features a discussion of painful affections of the lower back. Most of the chapters, however, may be described essentially as adequate, comprehensive, and direct.

No outstanding weaknesses or obvious misstatements were encountered. A few subjects, notably resuscitation and chronic empyema, are discussed so briefly that these sections of the textbook will be of little value to the student or practitioner who is seeking information on these subjects.

One may well question the logic of the arrangement of some of the material in this book. The chapters on roentgenology and gynecology inserted after plastic surgery and preceding the sequence "The Head," "The Neck," "The Breast," etc., appear to be out of place. However, as the index is adequate, no difficulty should be encountered in discovering the material to be found in these or in any other chapters.

Everything considered, Christopher's *Textbook of Surgery* deserves high recommendation. As a modern, practical textbook of surgery, it has no superior in the English language.

Post Graduate Surgery, Vol. I. By Rodney Maingot. Two volumes. Pp. 1742, with 1980 illustrations. New York, 1936, D. Appleton-Century Company, Inc. \$15.00 each.

This volume, the first of a group of three under the title *Post Graduate Surgery* by British authors, appears with an American foreword by Dr. Eugene H. Pool and an introduction by the late Lord Moynihan. The editor is Mr. Rodney Maingot, senior surgeon in the Royal Waterloo Hospital. This volume of 1742 pages contains in five parts chapters on the following subjects: the abdomen, the rectum and anus, x-ray diagnosis, and radium treatment. Twenty authors have pooled their knowledge from special fields to make this an authoritative text. A complete and useful index is appended also.

In three major sections written by the editor, viz., surgery of the stomach and duodenum, the biliary passages, and the spleen, a standard of excellence has been set which is rarely surpassed in the writing of medical texts. The well-balanced and temperate consideration of the subject matter in all these sections is deserving of high commendation. Sections equally meritorious are written by Hamilton Bailey on the vermiform appendix, in which are well described the operative treatment as well as the conservative management of late cases; by A. John Cokkinis on intestinal obstruction and peritonitis, and by W. Ernest Miles on the rectum and anus. The latter section alone occupies 222 pages. The chapters on anesthesia, x-ray diagnosis, and radium treatment, though considerably briefer, are well done and constitute reliable sources for useful information in each field.

The task of an editor in directing the publication of a work of this kind is no light matter, and the difficulty of securing the same standard of performance by all authors becomes readily apparent. The services of an artist whose function it would be to try to have all illustrations conform to a certain standard could be well employed in such an enterprise. The appearance of the text would thereby be appreciably augmented. Duplication, some of which is useful, has also crept in. This is particularly evident in the chapter on peritonitis, where some of the details of the primary conditions previously described are again repeated. The treatment of the subject of ileus by the late H. Tyrell-Gray is so unusual and unique that despite 210 pages of excellent discussion of the subjects of intestinal obstruction and peritonitis by Cokkinis, it does not appear out of place. Some may still question whether Gray satisfactorily substantiated the distinction which he makes between active and paralytic ileus. The chapter on the pancreas is all too brief, and no reference is made to the operation of Allen Whipple for carcinoma of the ampulla; hypoglycemia due to hyperinsulinism receives late mention. Certain

provincial expressions not understandable to the general reader are found here and there. The reader may, with some justifiable irritation, inquire what is the Graham ladder diet or the Lawrence line ration diet and what is kerol.

The reviewer would have liked to have seen Devines' interesting operation for carcinoma of the colon described at greater length; yet no reference to it appeared in the bibliography. Mr. Wakeley in the section on the colon also minimizes the importance of acute obstruction of the colon and fails to point out the danger of perforation, particularly of the cecum. One is led to wonder why exteriorization of the colon is spoken of as the Mikulicz-Paul operation, particularly since Mikulicz's description of the operation was made in 1903, and Paul, a native Englishman, gave a lucid description of his operation in 1900. It should also not be forgotten that exteriorization of the colon was well described by the Danish surgeon, Bloch, in 1892. Cokkinis leaves the reader with the wholly erroneous impression that roentgen examination with the scout film of the abdomen is unnecessary in the diagnosis of bowel obstruction. His statement that sudden decompression of the bowel obstruction is dangerous would appear to need more proof than is now available upon the matter. In the light of Eiselsberg's experience with gastric exclusion performed simultaneously with gastroenterostomy for duodenal ulcer, this procedure would not seem to have much justification.

This authoritative and practical volume on surgical subjects by British authors is not a provincial surgical treatise; it has absorbed the best and newest from all surgical literature. It should find an enthusiastic reception by an audience of American surgeons. The second volume has already appeared, and the third will be awaited with interest.

Textbook of General Surgery. By Warren H. Cole and Robert Elman. New York, 1936, D. Appleton-Century Company.

The ever widening realms of surgical endeavor, the rapid advances made during short periods of time, the present-day tendency of intensive specialization, and the diversified and controversial opinions held on many subjects make the writing of a satisfactory textbook of general surgery an almost Herculean task. Thus, the appearance of a new textbook covering the entire field of surgery compiled and edited by two authors is worthy of some consideration, if from no other standpoint than to applaud the indomitable courage and the diligent assiduity required in the preparation and completion of such an operose undertaking. The authors deserve more than this commendation, however, as they apparently fully appreciated these obvious difficulties and have confined themselves, as they state in their exordial remarks, to the simple compilation of the more important principles of surgery for the undergraduate student. In the prefatory words of Evarts Graham, to whom the book is respectfully dedicated, it "is the outgrowth of a course given to the junior students of the Washington University School of Medicine." With this idea in mind and without entering on any lengthy encomium, it should be remarked that the authors merit unstinted approbation.

The scheme and manner of presentation differ little from that of most surgical texts. The early chapters consist of compendious considerations of the underlying principles of inflammation and repair, surgical bacteriology, sepsis and antisepsis, surgical methods, wounds, miscellaneous infections, and shock and hemorrhage. These are followed by complete but succinct expositions of the more important surgical diseases affecting the various systems of the body. The section devoted to the investigation of the emergency prostrate patient is noteworthy for its lucid and instructive manner of presentation. As would be expected, the

No outstanding weaknesses or obvious misstatements were encountered. A few subjects, notably resuscitation and chronic empyema, are discussed so briefly that these sections of the textbook will be of little value to the student or practitioner who is seeking information on these subjects.

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hospitals. Their grave misgivings about transurethral reaction as performed by those without adequate training are more than justified; they are perhaps a trifle too skeptical of its value and safety in more experienced hands.

There are admirably concise discussions of stone and tuberculosis, and the consideration of neoplasms of the urogenital tract is noteworthy; however, it is doubtful whether many urologists have learned to expect quite so much from irradiation, or to be quite so skeptical of surgery as are the authors.

Their observation that irradiation controls 29 per cent of all testicular tumors for five years, while radical operation controls but 17 per cent of selected cases is most interesting. The technique of irradiation with the x-ray and with radon is very fully described.

Traumatic lesions are well considered, and the discussions of pre- and postoperative care and of derangements of the sexual function are especially well presented.

On the other hand, certain criticisms should be offered. The book contains many widely used medical and urologic terms which cannot win the approval of the purist, such as the use of "physiology" for function, "perinephritis" for "perinephrie," or "perirenal" and "retropylitis" for "retropelvic."

More important than these trivialities is the absence of good general discussion of neurogenic visceral dysfunction and of pseudohermaphroditism, a lack common to most textbooks of urology. Nevertheless, the treatment of the paralyzed bladder traumatic myelitis by the avoidance of catheterization is admirably presented.

The section on operations is valuable but occasionally somewhat sketchy, particularly in the case of hypospadias where the only method of straightening the penis which is described is that of Hagner, and the only method of constructing a new urethra that of Ombredanne. It would be difficult for any one to comprehend fully the details of the latter operation from the description in the text unaccompanied by diagrams. Surely the eminently satisfactory operation of Thiersch deserves mention; the subject should not be dismissed by saying that "the future of hypospadias lies in the hands of the plastic surgeon." Such problems belong definitely to the urologist.

It is difficult to refrain from taking issue with certain statements. For example, it is doubtful whether the bladder must always contain 600 c.c. to be palpable, that the calices, pelves, and ureters normally lie empty, that excretory urography would often be valueless except for the making of cystograms, or that the nocturia which precedes retention in prostatism is due to renal polyuria secondary to impaired renal function since it often occurs before the renal function is impaired.

The statement that approximately 5 per cent of urologic patients die of pulmonary embolism is apparently a misprint; also, one may question whether it is justifiable to tell students dogmatically that sudden emptying of the distended bladder is dangerous without submitting adequate proof that this is so.

Finally it would be interesting to know what the authors meant by "vicious sexual hygiene," a rather vague term long in honorable use in urology.

Notwithstanding these minor criticisms, this is an unusually satisfactory textbook of urology which should prove very useful to general practitioners and students.

Diseases of the Coronary Arteries and Cardiac Pain. Edited by Robert L. Levy. Pp. 426, with 74 illustrations. New York City, 1936, The Macmillan Company. Price \$6.

The subduing of the great epidemic diseases and the concomitant "aging" of our population have resulted in the elevation of diseases of the heart to the position of prime importance in medicine. The great increase in death rate from heart disease is practically entirely due to the increase in heart disease associated with

subjects of liver, gallbladder and biliary tract disease, and thoracic surgical diseases are exemplary dissertations for undergraduate students. It is regrettable that not as much can be said for the last three chapters, which respectively consider the endocrine glands, gynecology, and the genitourinary diseases. However, the usual characteristic fluctuation in emphasis of various phases of surgery, according to the particular interest of the authors, is remarkably minimized.

Following each chapter there is a concise, pertinent, and up-to-date bibliography for those desiring greater detail. The illustrations are profuse, demonstrative, and in general commensurate with the text, but they are unfortunately marred by the mediocrity of the drawings. Although many of the illustrations are borrowed from other sources, particular attention is called to the inaccuracy of crediting the original author.

Its study is particularly recommended to the junior and senior medical students, who as a group require emphasis upon pathogenesis and necessitate the presentation of the subject matter from the physiologic point of view in order to better understand the rationale of therapy. In accordance with this idea, the authors have faithfully and laudably achieved their difficult task.

Urology. By E. L. Keyes and R. S. Ferguson. Sixth edition. Cloth. Pp. 697, with 343 illustrations. New York and London, 1936, D. Appleton-Century Company, Inc. \$10.00.

The recent appearance of a number of textbooks of urology differing considerably one from the other raises the question of what such a book should aim to accomplish. The resulting speculations have led the reviewer to formulate the following objectives as reasonable.

1. To supply the fundamentals in easily assimilable form to the medical student;
2. to answer the practical questions of the practitioner who is not a specialist;
3. to supply the student of urology as a specialty with an understanding both of the fundamentals and of the details; and to serve him and the urologist already trained as a source of reference to the literature.

Keyes' and Ferguson's *Urology* fulfills the first two objectives but does not fulfill the third because it contains no bibliography, an omission doubtless made deliberately to avoid excessive bulk. Moreover, it is no longer possible to treat urology extensively from the third point of view in less than two, or possibly even three, volumes.

Especially deserving of praise are the sections on instrumentation with emphasis on its purposes and dangers. There is a tendency among those just attaining some proficiency in instrumentation to regard "passing the cystoscope" as a neat trick and to forget that diagnostic cystoscopy is only a means of making a diagnosis and not an act in itself. Such persons need the cautious reminders expressed in these reactions. The tests of renal function are well discussed from the viewpoint of practical urology. The discussion of congenital anomalies is good but fails to give the student a working conception of pseudohermaphroditism.

The attitude of the authors toward such controversial topics as nephralgia and renal sympathectomy, nephroptosis and nephropexy, and ureteral stricture and dilatation is pleasingly thoughtful and conservative. Their view of postoperative urinary retention with its urgent plea for early and frequent catheterization to prevent damage to the bladder by distention ought to be brought to the attention of every surgeon.

The section on prostatism is noteworthy for its frank discussion of the mortality of prostatectomy under the less than ideal conditions that prevail in most public

tainers. This would seem to provide more protection than it actually does, for the law is worded so as to require the government to prove that claims are fraudulent before any action can be taken against the producer. He cannot be convicted under this law unless it can be proved that he actually knows that the claims are false. If he can convince the jury trying the case that he, himself, believes in the value of his product, he will be acquitted. Furthermore, this law does not hold the manufacturer of a proprietary or patent medicine legally responsible for false claims which are made for his product through the various channels of public advertising. Proprietary medicines formerly labeled as specific cures for cancer or diabetes continue to be sold, immune from prosecution, merely by a change of label and a limitation to collateral advertising of their claims to cure cancer, diabetes, etc. Such advertising, particularly since the advent of the radio, reaches infinitely more prospective buyers than could corresponding claims on the label of the package.

The present food and drug act provides no protection against the potentially dangerous drugs which are contained in certain "patent medicines." Detailed reports are given of serious toxic results, and of several deaths from the use according to directions of various nationally advertised and widely sold medicinal and cosmetic preparations. It is illuminating to see detailed reports of the constituents, the claims, ownership and promotion methods of many of America's most famous remedies, such as Crazy Crystals, Cascarets, Jad salts, Tanlac, Marmola, Fleischmann's yeast, Cherry Pectoral, Vick's VapoRub, Lydia Pinkham's Vegetable Compound (the virtues of which were recently extolled in a full-page advertisement in the new magazine *Life*), etc.

The fearlessness and frankness of the author in discussing these products excite the admiration of the reader. She would not dare to make the statements she does if they were not true. Startling disclosures are presented concerning the adulteration, mislabeling, and false claims made for many foods which effective and persistent advertising has led the American public to accept as standards of excellence. The possibilities of poisoning with lead arsenate and pyrethrum from fruit and vegetables which have been sprayed with insecticides is considered at some length.

The final chapter of the book presents an interesting story of the recent attempts to induce Congress to pass a new and more effective food and drug law. The bill which was formulated largely by the food and drug administration was introduced by Senator Copeland in June, 1933. This proposed law would not do away with the so-called patent medicine business, but it would give the consumer a better idea as to what he is buying, and it would prevent false advertising claims as to the value of these various preparations.

The introduction of this bill gave rise to immediate and determined activity on the part of the patent and proprietary medicine groups and associations. They usually referred to the bill as the Tugwell bill because Mr. Tugwell had been interested in having some law enacted which would give the American public better protection in this regard than it has at present. On the one side, the food and drug administration with the backing of certain consumer groups has been attempting to convince congressional committees that a better law should be passed. On the other side, the manufacturers and jobbers of proprietary medicines, employing powerful lobbies, bringing pressure upon advertising agencies and through them upon newspapers, magazines, retail druggists, beauty parlors, and other retail corporations, have been attempting to block the passage of any law which will curtail their profits. It is a most interesting and enlightening, although disheartening, story.

The author concludes that "there is going to be a law." If the American public were familiar with the facts presented in this book, this prediction doubtless would come true and that very promptly. Unfortunately, facts such as these will not reach any considerable proportion of the population. Public opinion will con-

hypertension and with disease of the coronary arteries. Within a period of only twenty years, our knowledge of the anatomy and the physiology of the coronary arteries, as well as our knowledge of the symptoms and signs of heart disease associated with disease of these arteries, has increased enormously. Within this same period of time the mechanism of cardiac pain has been elucidated. Surgical measures for the relief of cardiac pain and for the treatment of the heart failure associated with disease of the coronary arteries have been devised quite recently. Knowledge in this field of such great importance to the physician is widely scattered in journals of physiology, pathology, medicine, and surgery.

Physicians and investigators have long felt the need for a comprehensive summary of our knowledge in this field. This work appears to the reviewer to meet admirably the needs of both the physician practicing at the bedside and the investigator working in the laboratory. Fourteen American physicians and scientists, who have themselves made valuable contributions to our knowledge of the coronary arteries and their diseases, have contributed authoritative chapters to this work. Every chapter has a comprehensive bibliography to guide the student who desires to delve deeper. The practicing physician will not only find chapters on the physiologic and pharmacologic background for a rational treatment of angina pectoris, coronary thrombosis, and congestive failure due to coronary arteriosclerosis, but he will also find chapters devoted to a description of the medical and surgical treatment of these conditions. The surgeon will find a brief but adequate treatment of the subject of "paravertebral alcohol injections, ganglionectomy, and posterior rhizotomy for the relief of cardiac pain" in James C. White's chapter on this subject. Blumgart's chapter on "total thyroidectomy for the relief of cardiac pain and congestive heart failure" will serve the surgeon as an introduction to this subject, upon which the last word has not yet been said. Claude S. Beck contributes a chapter on "the development of a new blood supply to the heart by operation" which every surgeon will want to read. It should serve as a stimulus to some of the younger surgeons to join Beck in pioneering in this field. The reviewer desires to recommend this book very highly to all physicians.

American Chamber of Horrors. By Ruth DeForest Lamb, New York, 1936, Farrar & Rinehart, Inc.

The title of this book suggests either a detective story or a glance behind the scene of an inquisition room of a prison or court. Actually it is neither. It is the inside story of the government's fight to protect consumers against danger to health, life, and pocketbook. The title is the name which the press applied to the exhibit of injurious and fraudulent products that the food and drug administration set up to illustrate defects of the existing pure food and drug law at the time that a revision of this law, the so-called Copeland bill, was being considered by Congress.

Realizing that a pure food and drug law exists, the public places infinitely more confidence in the protection which they think this law provides than the facts of the situation justify. This book shows, largely by illustrative cases, the loopholes in existing legislation which permit well-known quacks to continue to exploit the public even though the character of their businesses is thoroughly understood by various agencies of the federal government. The present law merely closes the channels of interstate and foreign commerce to products which are adulterated and misbranded.

The existing pure food law was enacted in 1906. In 1912, it was amended to forbid false and fraudulent therapeutic claims on labels of patent medicine con-

SURGERY

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Original Communications

A METHOD OF TESTING THE SUPERFICIAL BLOOD CIRCULATION FOR CONSIDERING THE INDICATION AND THE PROPER LEVEL OF AMPUTATION

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JUDGMENT as to whether an amputation is indicated in cases of disturbances of the blood supply is often very difficult. If the indication is clear, the choice of the site for the severing of the limb may offer still more delicate problems. The classic procedures of palpation of the arteries, the observation of the color of the skin, and the examination of the skin temperature by hand fail as a rule to give accurate information of the efficiency of the blood supply. The use of the blood pressure apparatus has been a step forward, and modern arteriography and oscillography have been fine contributions to the study of circulation. But arteriography is a rather complicated intervention, and probably not without danger for diseased arteries. Arteriography, as well as oscillography, only gives us an account of the capacity of the larger arteries and not of the blood supply to the tissues. Finer collaterals, which, for instance, have developed as substitutes for closed main arteries, may escape discovery even by arteriography, which has been most successful from a technical point of view, and may give no response to the oscillograph and still be quite efficacious in retaining the vitality of the tissues.

Examination of the blood supply to the integuments has been enhanced by the instrumental methods of testing the skin temperature by the thermocouple (Brooks) or the usual thermometer under a cover of felt (Ipsen). But when directly applied, they only give account of the blood supply under the actually existing conditions and not of the powers of reserve to which the body has to resort in cases of larger claims on the blood supply, as, e.g., after surgical interventions.

Received for publication, November 11, 1936.

time to be based largely upon misinformation disseminated by press, radio, and other advertising agencies which profit handsomely from the patent medicine business as it now exists.

The appendix contains much interesting and valuable information relative to the fortune of the Copeland food and drug bill in Congress; the President's message to Congress relative to this act; the roll call of the Senate on the proposed amendment to this bill; the provisions which are essential in an act to protect the consumer; the costs and ingredients of well-known cosmetics; the quality grades of many widely advertised canned foods; the list of members of the Proprietary Medicine Association and of the Institute of Medicine Manufacturers (the reviewer was interested to find twelve members of the latter association in his own city, ten of which were firms that he did not even know existed); and the resolution of the American Federation of Labor relative to this law. The bibliography is extensive and specific for the various chapters of the book.

The author of this book has made a significant contribution in presenting as an absorbing story a subject in which everyone is, or at least should be, vitally interested. Physicians will find it illuminating and interesting and will do well to recommend it widely.

Books Received

The receipt of books is acknowledged in this section and this statement must be regarded as sufficient acknowledgment of the courtesy of the sender. Selections will be made for more extensive review dictated by the interests of our readers and as space permits.

WILLIAMS OBSTETRICS: A TEXTBOOK FOR THE USE OF STUDENTS AND PRACTITIONERS. By *Henricus J. Stander*, Cornell University Medical College. Cloth. Price \$10. Seventh edition: A revision and enlargement of the text originally written by J. Whitridge Williams. Pp. 1269, with 729 illustrations. New York, 1936, D. Appleton-Century Company, Inc.

LAW OF DRUGS AND DRUGGISTS. By *William R. Arthur*, University of Colorado. Cloth. Price \$3. Pp. 487. St. Paul, 1936, West Publishing Company.

THE PHYSIOLOGY AND PHARMACOLOGY OF THE PITUITARY BODY. By *H. B. Van Dyke*, Professor of Pharmacology, Peiping Union Medical College, Peiping, China. Cloth. Price \$4.50. Pp. 577, with 55 illustrations. Chicago, 1936, University of Chicago Press.

LECTURES ON EMBOLISM AND OTHER SURGICAL SUBJECTS. By *Gunnar Nyström*, Professor of Surgery, University of Uppsala, Sweden. Cloth. Price \$3. Pp. 213, with 66 illustrations. Baltimore, 1936, Waverly Press, Inc.

THE LUNG. By *William Snow Miller*, Emeritus Professor of Anatomy, University of Wisconsin. Cloth. Price \$7.50. Pp. xiv plus 212, with 122 illustrations, 20 in colors. Springfield, Ill., 1936, Charles C. Thomas, Publisher.

Erratum

On page 89 of the January issue, in the article by Scudder, Zwemer, and Truszkowski entitled "Potassium in Acute Intestinal Obstruction," paragraph 2 of the summary should read:

"The potassium rise is ascribed to some combination of dehydration, tissue breakdown, and action of bacterial toxin, with consequent adrenal and renal dysfunction resulting in inadequate potassium elimination."

During the past twenty years, I have employed a method for this kind of examination which in two ways seems to me to be superior to those mentioned above:

1. In producing an irritation of such an intensity that the effect on the capillaries and small arteries becomes very large, probably maximal, thus giving the largest possible degree of hyperemia which is feasible in the actual condition.

2. In using the degree of another inflammatory reaction, viz., exudation and its clinical effect, the edema, as a measure of the vital response of the tissues to irritation and the presence of the lesion.

The method is based on brief *freezing of the skin with the aid of carbon dioxide snow*.

Fluid carbon dioxide is sprinkled in a little bag of velvet or leather, where it gathers in the form of snow. The snow is shaken out in a

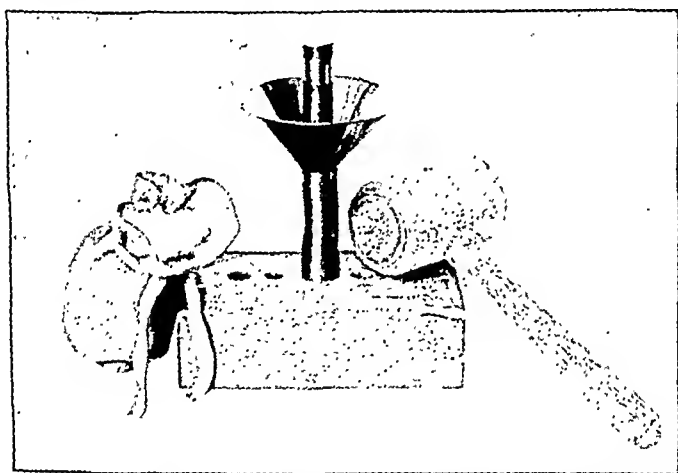


Fig. 1.—Bag with carbon dioxide snow, funnel, piston, and mallet for forming the ice-rod.

metal tube with a diameter of about 20 mm. and packed to a firm rod with the aid of a metal piston and a mallet (Fig. 1). The ice-rod is seized with a piece of gauze, its sharp edges are rounded off by sliding a piece of metal against them, and then the end of the rod is pressed against the skin for three seconds successively over the area to be tested in spots at a distance of 5 to 10 cm. from each other. The procedure begins at the most distal point to be tested and continues upward at a smart pace. For comparison the same procedure is repeated on the corresponding parts of the other limb.

In normal cases the white frozen spots of the skin thaw to normal consistency and color in *about one minute*. And then in another minute, the *hyperemia* sets in and soon becomes maximal.

The speed with which the hyperemia sets in and the grade of its intensity afford a certain guide as to the condition of the arterial supply

Thus it has been a quite appropriate suggestion to try to *produce a hyperemia* in the diseased limb or at least in its integuments, and to examine the amount of increased filling of the capillaries as a method of judging the vitality in the actual parts. By such a procedure it would also be possible to get an *accentuation of the limits between satisfactory and insufficient blood supply*.

Moszkowics proposed (1907)¹ to produce this hyperemia by strangling the limb for a few minutes with an elastic band. This leads to an increased filling of the capillaries (by a temporary paralysis of the vasoconstrictor nerves?) to such an extent as the arteries are capable of supplying them. In most common cases where this examination might be desired, viz., the cases of arteriosclerotic gangrene, the method, however, seems to involve a certain risk of the chalk-inerusted, frail walls of the arteries being injured by the compression and thus eventually causing a more extended occlusion of the vessels by thrombosis. That is exactly one reason why we do *not* use Esmarch's bandage for the amputation itself in such cases. Moszkowics later (1913)² expressed the opinion that strangling is often unnecessary and that the changes of color of the skin by elevating the limb or bringing it into a dependent posture suffice for the test: in the case of a disturbance of the arterial supply, the elevated limb may assume the pallor of a corpse, and the increasing rubor of the dependent limb may be delayed. It is, however, a fact that the changes of color due to this simple method are as a rule too slight to be of sufficient value for testing the amount of the blood supply. Even with the original Moszkowics method, the hyperemia is not always well pronounced, and its limits may be quite diffuse. This may be still more the case in producing the hyperemia by rubbing the skin, even if in so doing an irritating substance is used, for instance, ether-alcohol (Sandrock, 1913).³

Lewis' cutaneous histamine reaction (the hyperemic "flare" after intradermal injection of 0.1 c.c. of a solution of histamine acid phosphate) has been used for the same purpose by De Takats and Mackenzie.⁵ I have no personal experience with this method, but I think, however, it may prove to be a good test.

As to the value of examinations of the superficial circulation for the decision of the proper level of an amputation, it must be remembered that a satisfactory response in the skin does not guarantee a sufficient blood supply to the deeper parts, especially to the bone. But as an orientation which, in most cases, corresponds rather well to the exact circulatory conditions also in the deeper tissues, the examination of the blood supply to the skin, however, is worth consideration. As has been said above, preference must thereby be given to methods which give us an account, not only of the actual circulatory conditions in the diseased limb, but also of its capability of responding to an increased demand for blood at the level in question.

When comparing the effect of the test on both extremities, it is essential to keep them in the same position, preferably the horizontal. In a dependent posture, the speed of refilling the anemized capillaries will increase manifold on account of the higher hydrostatic pressure and the stasis in the veins, which throw their blood back in the emptied capillaries. For instance, when the refilling in the horizontal posture takes a time of 4 seconds, it may require only 1 second when the extremity is dependent.

In normal conditions an *edema* begins to appear in the spot after 10 to 15 minutes and soon brings about a slight, sharply limited elevation of the skin. At the same time, the hyperemia vanishes under the increasing compression of the inflammatory exudate in the tissues, and the

Normal male, 59 years, lower part of upper arm

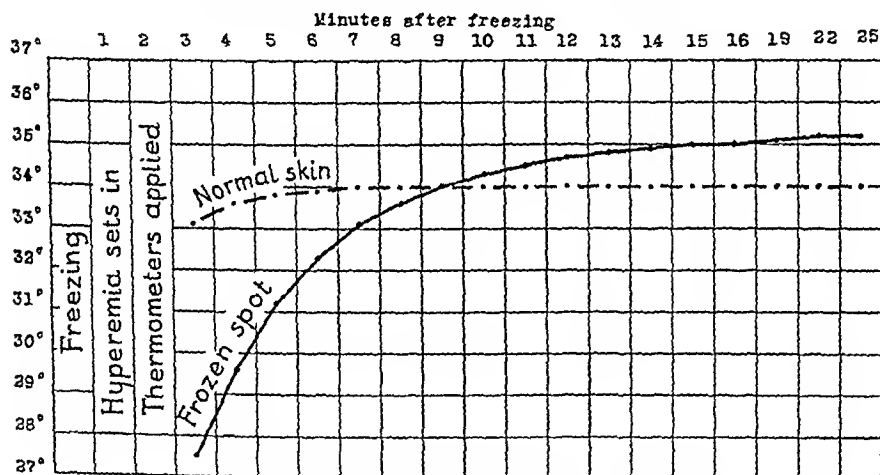


Fig. 4.—Temperature of the frozen spot.

swollen spots of the skin become more or less pale in contrast to a diffuse corona of hyperemia in the surrounding parts (Fig. 5). By and by the edema disappears, eventually leaving a little blister on the surface of the skin. The hyperemia returns, but some hours later the red color cannot be pressed away; the blood is now partly extravasated. The spot assumes a more cyanotic color which fades away in a few days, succeeded gradually by a faint pigmentation. The epidermis shows the usual thickening and exfoliation of its superficial layers as sequels of the slight "burn."

The freezing itself gives almost no discomfort and affords no subsequent inconvenience to the patient.

The temperature of the frozen spot has been examined with the aid of a usual maximum skin thermometer applied on a single frozen spot

(Fig. 2). But a more accurate means of testing is possible when the maximum effect is reached. With the tip of the finger, we compress the hyperemic spot for 5 seconds, then hastily remove the finger and with a stop-watch count the seconds which elapse until the spot has again reached its maximal filling with blood (Fig. 3). Under normal condi-

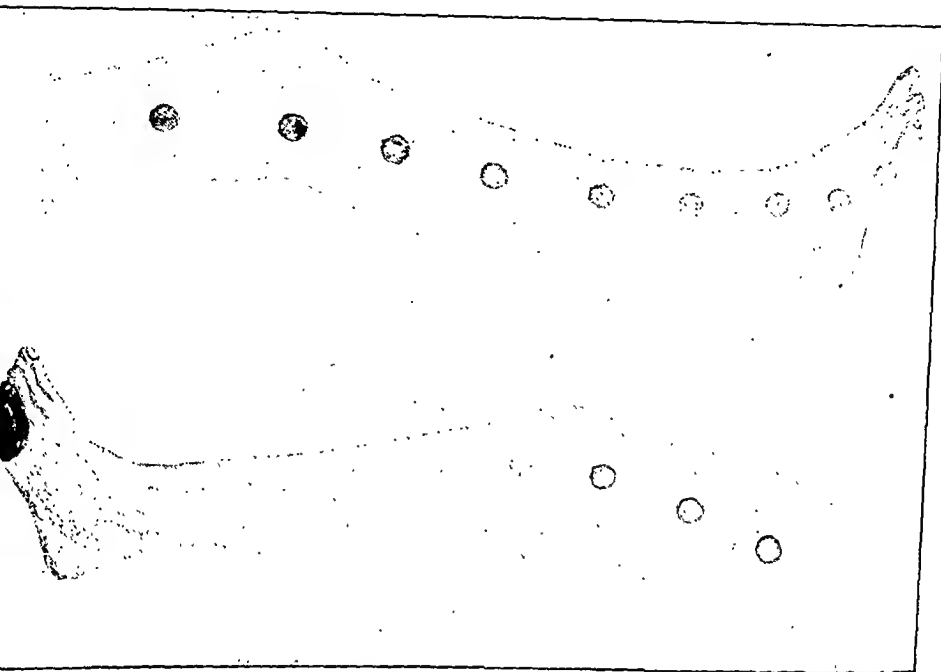


Fig. 2.—Spots of hyperemia about 3 minutes after the freezing in a case of arteriosclerotic gangrene of left foot. Upper figure, sound leg: maximal hyperemia in all spots but the lowest on the foot where its intensity is somewhat feebler. Lower figure, gangrenous leg: almost no response to the freezing on lower half of leg and on the foot.



Fig. 3.—The refilling test. 1, pressure with finger 5 seconds; 2, finger removed: anemic spot; 3, beginning refilling of blood; 4, full hyperemia.

tions and in a horizontal posture, the refilling of blood takes an average time of from 1 to 2 seconds. The return of the blood to the anemized spot is of a flaming character. With a bad arterial supply, the time may be extended to 10, 15, 20 seconds, or more. The intervals are noted with ink on the skin at the side of each spot and inserted in diagrams of corresponding sides of both extremities stamped on the history sheet.

applications I have found it safer to choose a somewhat higher level, 10 to 15 cm. above the lowest spot with good response of hyperemia and edema.

CASE REPORTS

The following short records and pictures give an idea of the method which makes further descriptions unnecessary:

CASE 1.—Man, aged thirty-five years. *Thromboangiitis obliterans (Buerger's disease)* of arms and legs. *Top of left long finger gangrenous.*

Oscillometric examination: oscillations on both arms definitely less than normal; on left arm less than on right.

Freezing response: normal with exception of base of long finger of left hand, where a faint hyperemia appeared later; the refilling of blood after anemization was delayed; and the wheal formation of the frozen area was delayed and reduced (Fig. 5).

CASE 2.—Man, aged fifty-five years. *Thrombosis of bifurcation of aorta with embolus of right femoral artery.* *Freezing response:* left leg normal, right leg no response below middle third of thigh during first 5 to 10 minutes, then hyperemia also in a spot on lower part of thigh (Fig. 6).

CASE 3.—Man, aged seventy-seven years. *Arteriosclerotic gangrene.* Since youth, following trauma, recurrent ulcer on left leg. Otherwise in good health. Last 2 years increasing circulatory disturbances of left leg. Gangrene of left foot and lower part of leg now set in. General condition, bad. No glycosuria.

Freezing test: after 3 minutes, hyperemia only in the spots above knee with decreasing intensity downward. Later on slight hyperemia also below the knee, less pronounced the more distal the level; only surmised in the vicinity of the gangrene (Fig. 7). Wheal formation only in the spots above the knee. Refilling of blood after anemization of the spots occurs with decreasing rapidity downward.

Amputation above the lowest spot showing wheal formation. Died ten days later of increasing weakness.

Postmortem: stump without necrosis of the skin. Wound partly open at the surface, necrosis of musculature and fasciae of the size of an almond in vicinity of ligature of femoral artery. In this vessel, there was a newly formed thrombus proceeding upward in the external iliac artery; nowhere did it seem to be of earlier date, and only adhered loosely to the wall of the vessel. The lumen of the artery was wider previous to the thrombus formation.

CASE 4.—Woman, aged eighty-one years. *Arteriosclerotic gangrene.* Fifth toe, almost whole of fourth, and lateral part of third toe of right foot mummified. Some superficial ulcers on dorsum of foot. Cyanotic discoloration and edema of whole dorsum and distal parts of sole of foot. Cyanotic discoloration of heel soon after admission. Rigid arteries on both sides. No varicose veins. No glycosuria.

Freezing response: normal on thigh and leg down to about a hand's breadth above ankle joint; the next spot beneath this level only faint red; on the foot only slight touch of hyperemia.

During the following months, gangrene proceeded to second toe and lateral part of great toe. Four lateral toes then detached under good demarcation. Wound shrinking with slack granulations. Great necrotic spot on heel, with good demarcation, surroundings cyanotic. Nowhere was pulse felt in popliteal artery or arteria dorsalis pedis.

with a diameter of about twenty millimeters under a cover of felt (Ipsen's method) and another thermometer applied in the same way on a control spot of the skin at the same level of the extremity.

During an interval of several minutes after the setting in of the hyperemia, the temperature of the frozen spot is lower than the temperature of the control spot. Under normal conditions (observations on two males of twenty-two and fifty-nine years of age, respectively) it does not reach the degree of temperature of the surrounding skin until about 8 to 9 minutes after the freezing, but then it continues to rise and reaches a maximum of 0.8-1.2 degrees Celsius or above the normal skin temperature at the same level of the extremity (Fig. 4).

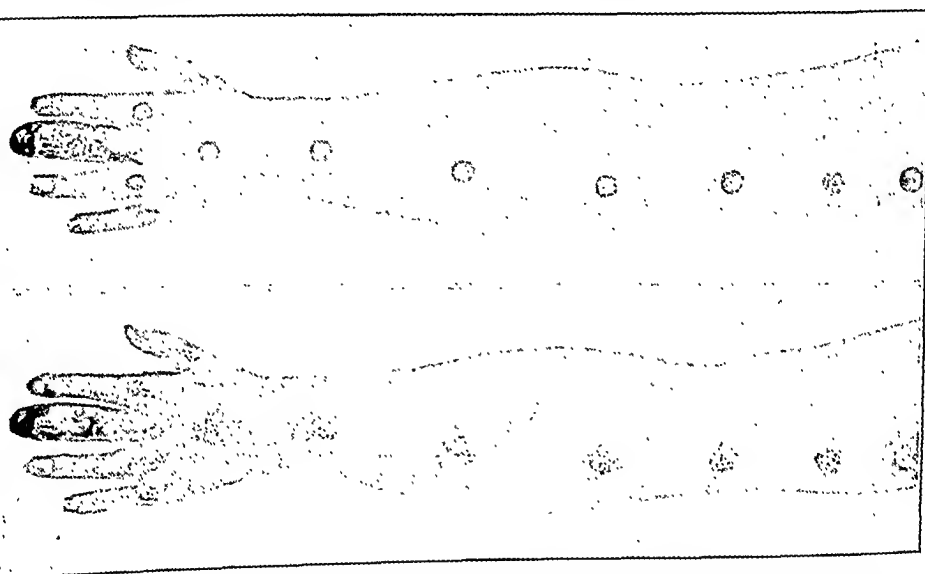


Fig. 5.—Freezing response in a case of Buerger's disease with gangrene of top of long finger: normal in all spots but at the base of the long finger, where both hyperemia and wheal formation are definitely reduced and delayed. Top figure shows hyperemia; lower figure, wheal formation.

This observation of hyperemia existing as long as 7 to 8 minutes before the temperature of the hyperemic spot has reached the normal level may possibly denote that the hyperemia at first is brought on by a dilatation of the capillaries alone, and that dilatation of the small arteries, which occurrence indicates a more active inflammatory reaction, sets in only after a certain time of "stupor," or perhaps of contraction of the arteries caused by the vigorous thermic injury. This suggestion is supported by the fact that edema begins to occur at about the same time as the temperature rises above the normal level.

As to the practical application of the results of the examination, I first tried to make the amputations immediately above the lowest spot which showed a good hyperemia and wheal formation, but in later

New freezing test in order to determine level of amputation (Fig. 8).

Sound leg: hyperemia in all spots, even on the foot, wheal formation in all spots, with exception of one spot on the foot (?).

Bad leg: hyperemia as on first examination two months previously, thus faint on foot and lower half of leg, normal above middle of leg. Wheals faint or absent below middle of leg; *quite unexpectedly a rather definite wheal, however, appears on lateral part of foot quite near border of the toe-defect*. Thus: superficial circulation above middle of leg rather good and not impaired during last two months in spite

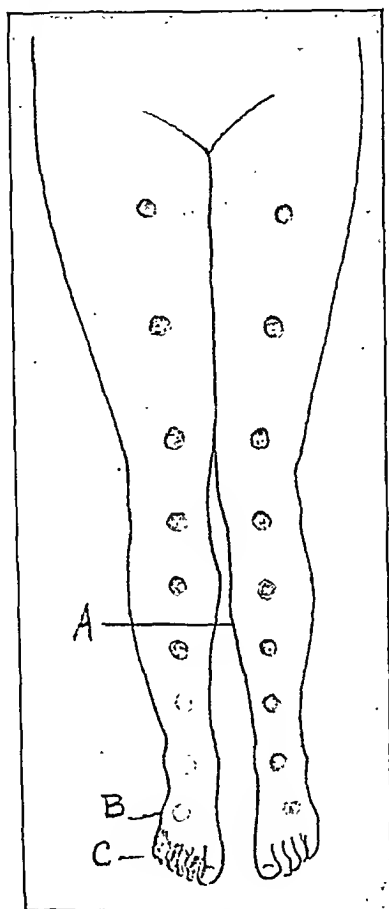


Fig. 8.—Freezing response in a case of arteriosclerotic gangrene: no hyperemia below middle of leg, but definite wheal in a spot on lateral part of foot. A, level of amputation; B, definite wheal; C, gangrene.

of proceeding toe gangrene; at the time below middle of leg bad, but irregular; the wheal formation in a frozen spot on the top of the foot denotes a restoration of circulation.

Amputation at middle of leg above the lowest spot with well-marked hyperemia and wheal formation. Weak pulsatile bleeding from both the tibial arteries. A narrowing of the anterior tibial artery by sclerosis was found immediately below the place where the vessel was severed. Both the tibial arteries could be injected rather well with minium emulsion, the posterior vessel with better results than the other. Vessels of the skin were thereby injected all over, though sparsely.

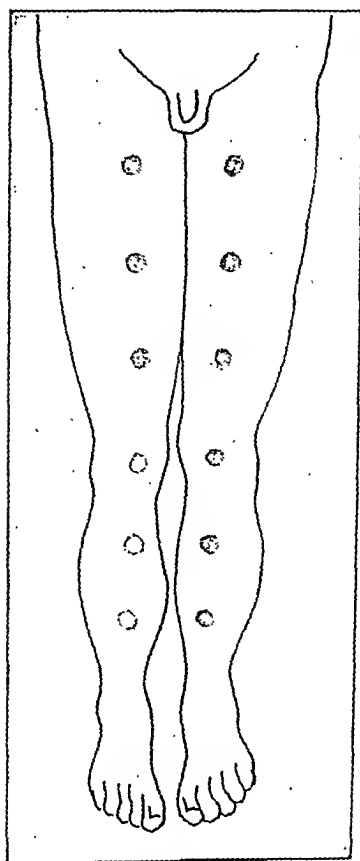


Fig. 6.—Freezing response in a case of embolism of the right femoral artery; no reaction below the knee.

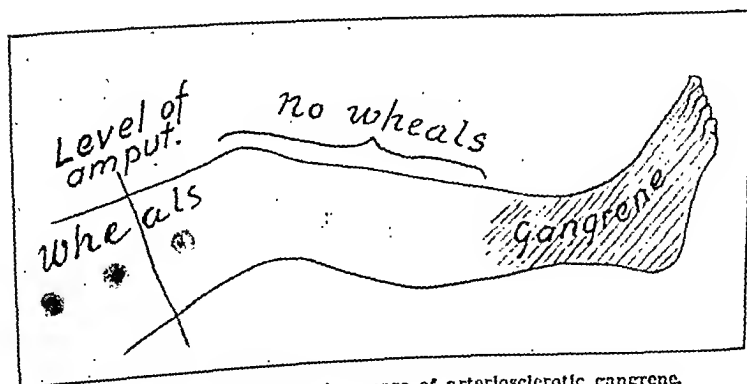


Fig. 7.—Freezing response in a case of arteriosclerotic gangrene.

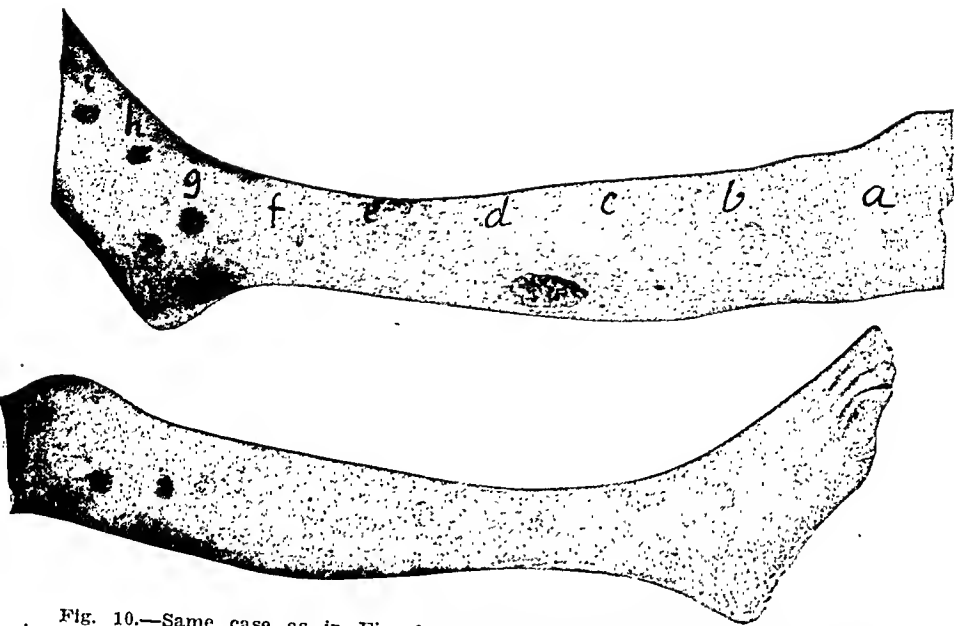


Fig. 10.—Same case as in Fig. 9. Photograph of hyperemic spots. Note no hyperemia in the vicinity of the ulcer. Top figure, bad leg: gangrene of great toe; no hyperemia between *e* and *c*. Lower figure, sound leg.

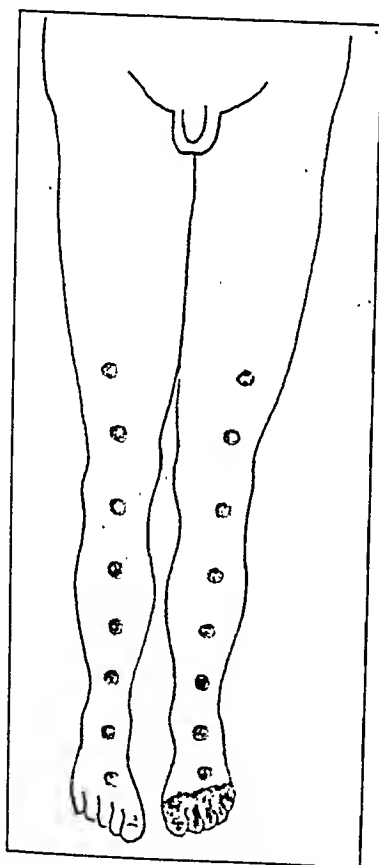


Fig. 11.—Freezing response in a case of diabetic gangrene. Note definite hyperemia in all spots right down to the edge of the gangrene.

The wound seemed to heal perfectly. Following a postoperative rise, the temperature was normal on the fourth to the sixth day, but then rose again. On the ninth day, the edge of the wound was somewhat red and moist to some extent. It was opened here, and about 2 cm. beneath this part of the wound a small cavity filled with grayish pus and some necrotic shreds was found.

The patient died from bronchitis two days later.

Postmortem: femoral artery shows a free lumen; wall of vessel without note. Lumen of popliteal artery free until last 2 cm. where a small thrombus is attached to the wall, yet only slightly narrowing the lumen. In the anterior and posterior

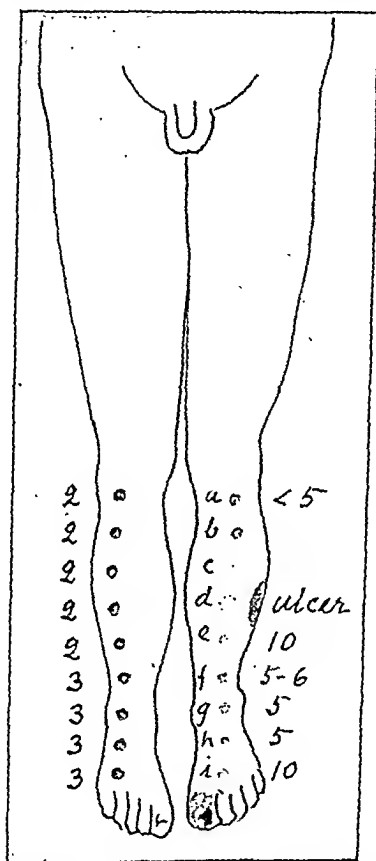


Fig. 9.—Freezing response in a case of arteriosclerotic gangrene. Sound leg: after 10 minutes, definite wheals in all spots. Bad leg: hyperemia delayed and reduced; almost no hyperemia in area surrounding ulcer; after 10 minutes no wheals. after 20 minutes definite wheals in spots a and b; faint edema in spots c and g; no edema in spots e, d, f, h, and i. Numerals at side of each leg indicate time in seconds for refilling of blood. Gangrene of left great toe.

tibial arteries, no thrombus and no narrowing of the lumen. No necrosis of musculature or skin with exception of the above mentioned. Definite arteriosclerosis of aorta and coronary vessels, fat infiltration of myocardium. Free excavated old thrombus in left ventricle.

CASE 5.—Man, aged seventy-five years. Gangrene of great toe and ulcer of leg.

Rather acute circulatory disturbances of left leg, pains in great toe; a few days later gangrene of toe set in. A week later pulsations of popliteal artery disappeared;

UNUNITED FRACTURE OF THE NECK OF THE FEMUR

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NONUNION in complete fracture through the central portion of the neck of the femur, or so-called intracapsular fracture, occurs more frequently than in any other bone. Not until the advent of the Whitman method of treatment was bony union of this fracture thought possible.

Sir Astley Cooper, and a majority of the older surgeons, believed that this fracture united only by fibrous tissue, and even since 1900, one will find statements to the effect that osseous union does not occur. The abduction treatment of Royal Whitman is the greatest advance that has been made in the treatment of this fracture; it was first described in 1896. This procedure was soon accepted by a majority of the orthopedic surgeons as Whitman and others gave conclusive evidence of securing osseous union in many cases, and it was thought that failures were of rare occurrence. As the years elapsed, however, it was found that even with this procedure union could be secured only in approximately 53 per cent of the cases. This leaves a rather large number of individuals, 47 per cent, in whom union does not occur.

In recent years, methods of internal fixation are largely supplanting this splendid procedure, and apparently the percentage of excellent results will be materially increased. However, even with any form of treatment, the physiology of the part is such that there will be many instances in which nonunion will occur. Also, a large proportion of fractures of the neck of the femur receive either inefficient treatment or no treatment at all, which results in nonunion.

The mechanics and physiology of this fracture are such that unless efficient treatment is administered, nonunion must invariably be expected. Since this fracture is of frequent occurrence, ununited fracture of the neck of the femur is common. The disability is great; in some with strong fibrous union, walking with a decided limp with more or less pain may be possible but the patient's endurance is very poor. In many cases, one or two crutches are required, and there is much pain and total disability. Much, of course, depends on the age and physical vigor of the individual, but, as is well known, the most frequent age of occurrence is above fifty years.

The important factors of anatomy and physiology of this region which are of practical value will be briefly discussed. In the normal

ulcer developed on outer side of leg. Frightful pains in leg and foot. Impaired sensibility of foot. No varicose veins. No glycosuria.

Freezing test (see Figs. 9 and 10).

The following week a definite improvement. Gangrene does not proceed. Remaining hyperemia in spots of left leg and foot still obviously feebler than that corresponding on sound side. Refilling of blood on sound leg now in 1 to 2 seconds, of "flaming" character, on bad leg at the knee in 3 seconds, near ulcer in 6, and on foot in 8 seconds.

CASE 6.—Man, aged eighty-two years. *Diabetic gangrene at the top of left foot.*

Amputation of right great toe two years ago, then amputation of right thigh for rapidly spreading gangrene. Well healed. For one year, ulcers have been present on the left great toe; now gangrene at the top of foot; other parts of foot cyanotic, swollen. Pulsations in arteria dorsalis pedis. Upper parts of foot warm. Peripheral arteries rigid and very tortuous. Glycosuria.

Freezing test (Fig. 11): hyperemia in all spots until quite near the well-defined demarcation edge of gangrene. Refilling of blood after 5 seconds of anemization, complete in 2 to 3 seconds in all spots. Wheal formation, however, only in the uppermost two spots. Died a few days after the examination.

Postmortem: injection of arteries with minium emulsion. Femoral and popliteal arteries well filled. Posterior tibial artery closed by thrombosis to some extent in upper third of leg and in whole middle third of leg, below this part well filled. Dorsal artery of foot well filled. Large parts of anterior tibial artery obliterated; only disconnected parts of its middle extent have received injection substance. Numerous beautifully injected small vessels in skin, musculature, and fasciae right down to border of gangrene.

Thus both main arteries of leg obliterated to a great extent, but collaterals well developed.

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If the greater and lesser trochanters are removed, the femur forms a tubular, curved lever; according to Meyer and Cullman, the trabeculae of bone are arranged in the same manner as the trajectories of stress of a crane, being produced along the lines of tension and pressure. The pressure trajectories pass from the inner aspect of the shaft parallel with the inferior border of the neck into the head; the trabeculae of tension pass from the external portion of the shaft parallel with the superior border. These cross each other at an acute angle of about 45° just distal to the head. Wolff applied this principle to other bones and organs of the body and developed his famous



B.

law of functional adaptation. Murk Jansen, of Holland, disputed this theory, pointing out that such lines are not analogous to the trajectories of a crane, since the trabeculae in the neck of the femur cross each other at an acute angle, whereas the trajectories of the crane cross each other at a right angle. Jansen believes that these lines are due entirely to forces of pressure and that tension has no material influence. Ronx has demonstrated that tension inhibits osteogenesis. Irrespective of that, whether caused by pressure and tension, or by pressure alone, this arrangement of the trabeculae is constant and has a practical application to the subject. As these lines cross in the neck of the femur, a triangle is formed in which there is less bone than in

adult, the neck of the femur forms an angle of about 125° with the shaft. In the aged, this angle is often decreased and may at times be as low as 115° . The weight of the body transmitted through the neck to the shaft is thus placed on an oblique axis, which, like the axis of a wheel, is mechanically efficient until impaired. The neck is also deviated forward at the junction with the shaft, forming an angle in the anteroposterior plane of about 15° . The head of the femur and



A.

Fig. 1.—Age, forty-six years. (A) Bone graft neck of left femur for ununited fracture three years after operation, showing practically normal contour of head and neck. (B) Same case thirteen years following bone graft. Note pressure trabeculations along line of weight-bearing.

the acetabulum are thus on a plane anterior to the shaft and to the trochanter. Consequently, if a bullet enters the femur perpendicularly to the center of the greater trochanter, it would pass below and posterior to the head of the femur; but if deflected upward at an angle of 125° and forward 15° , it would pass through the center of the femoral head.

shaft of the femur. The ischiofemoral band arises from the ischium between the lesser sciatic notch and the obturator foramen and is inserted into the greater trochanter in front of the insertions of the piriformis tendon and into the superior and posterior parts of the neck of the femur. The anatomy of the muscles of this region is well known, and requires no description except to mention the powerful external rotators which play a definite rôle in this fracture. The gemelli and obturator internus are said to rotate the head of the femur



Fig. 3.—Age, fifty-one years. Bone graft after considerable absorption of neck. Almost normal function.

backward after fracture. The iliopsoas and piriformis pass over the neck of the femur, and it has been suggested that they become caught between the fragments in femoral neck fractures, although the probability of this is doubtful.

As an adequate blood supply is the most important factor in the production of callus, a thorough knowledge of the circulation is necessary for an understanding of the process of healing. Wolcott has recently demonstrated an anastomosis between the arteries of the ligamentum teres, the head, and the posterior capsule. When a

other portions of the neck, producing a weak area which was described by Ward in 1838, and is known as Ward's triangle, through which a fracture of the neck of the femur usually occurs.

The hip joint is supported by powerful ligaments and muscles. The articular capsule is attached medially about the rim of the acetabulum slightly nearer the rim below and posteriorly, than it is above and anteriorly. At the femur, the capsule is fixed anteriorly to the anterior portion of the greater trochanter, along the anterior intertrochanteric line, inferiorly on a level with the lesser trochanter, and posteriorly

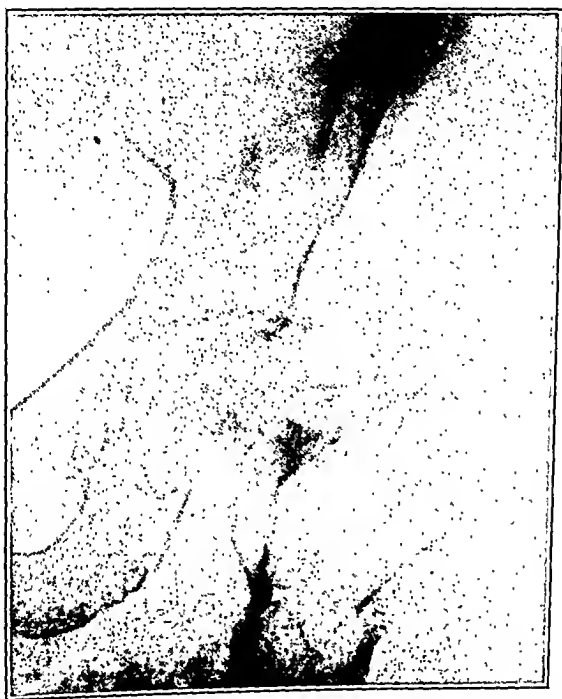


Fig. 2.—Age, forty-eight years. Bone graft operation following ununited fracture of neck of femur with marked absorption of neck. Solid union four months after operation. Osteotomy changed thrust of hip slightly.

along the base of the neck of the femur above the posterior intertrochanteric line, but leaving an extracapsular space of about three-fourths of an inch. The thickness and strength of the capsule varies in different regions, as there are three sets of auxiliary fibers, only two of which are of sufficient importance to be considered, i.e., the iliofemoral and the ischiofemoral ligaments. The iliofemoral, or Y-ligament of Biglow, is the strongest ligament in the body; it is attached above to the ilium immediately below and behind the anterior inferior spine, and is inserted into the greater trochanter and into the anterior intertrochanteric and spiral lines as far as the medial border of the

action may impair circulation and callus formation. Stress of this nature would be eliminated by internal fixation, or osteotomy, as described below.

3. Osteoporosis or bone atrophy with more or less fatty substitution and increase in size of Ward's triangle as above described.
4. Inefficient reduction, fixation, and after-treatment.
5. Weight of the body is transmitted on a more or less transverse plane through the site of fracture.

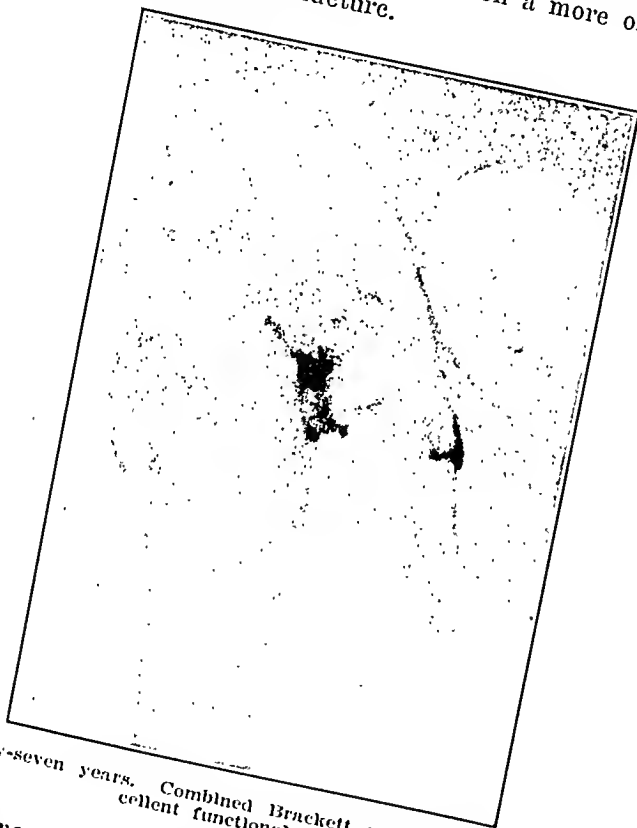


Fig. 5.—Age, fifty-seven years. Combined Brackett and shelf operation with excellent functional result.

6. Any movement causes a shearing action at the point of fracture which is always conducive to the organization of bone on the surface of the fragments and not across the line of fracture.
7. The normal process of union is impaired, as callus is derived chiefly from the distal fragment. All callus is intermediary, there being no reaction on the part of the periosteum, since the cambium layer of the periosteum on the femoral neck is said to be absent.
8. Union is always delayed when compared to other fractures, and a permanent status of nonunion occurs in those not reduced in approximately thirty days.

femoral neck fracture occurs, the outer fragment of the shaft of the femur is rotated outward and displaced upward. Outward rotation is produced by three forces; first, by the reflex contracture of the powerful abductor and external rotator muscles; second, by the ischio-femoral ligament which is made tense as the fragments separate; and third, by the force of gravity which is influenced by the angle of attachment of the foot to the leg. The outer fragment is thus on a plane above and facing directly forward, being completely separated from the proximal fragment or head, which is usually rotated backward by the obturator internus and gemelli.



Fig. 4.—Age, fifty-nine years. Bone graft maintaining position of extreme coxa valga after complete absorption of neck. Resultant change of weight-bearing. Excellent function. Same principle as osteotomy. This procedure in 1929.

The theories of the more frequent occurrence of nonunion in this region may be considered as follows:

1. Deficient circulation due to severance by the fracture of the main blood supply to the head of the femur which must depend upon vessels in the ligamentum teres and which may be more or less decreased in lumen as age advances.
2. The circulation is regarded by some authors as sufficient to secure union in those cases accurately reduced but admit that the shearing

of specimens in our laboratory and have corroborated Santos' conclusions. These changes deduced from the investigation of Santos may be enumerated as follows: the head may remain alive, as indicated by roentgenologic examination which demonstrates that the bony structure may become atrophic to the same degree as the surrounding bone in the ilium and the trochanters; or the head may die and become a sequestrum, as demonstrated by the bone retaining the same density



Fig. 7.—Age, fifty-eight years. Whitman reconstruction operation with almost normal function.

as at the time of the fracture, the sequestered head, therefore, remains opaque or dense, standing out in marked contrast to the surrounding atrophic bone.

Microscopic examination of the living head demonstrates atrophic changes; the trabeculae become thinner, and the narrow spaces are increased in size and substituted by fat. The articular cartilage becomes thinner, and the subchondral marrow spaces may so enlarge that the encrusting cartilage sinks below the surface, thus causing an ir-

9. Functional use before nature has had sufficient time to firmly consolidate new bone, impairs, or it may even cause disintegration of the reparative process.

10. The synovial fluid may possibly have a deleterious action upon callus production.

11. The head is a terminal fragment; somewhat similarly, union often fails elsewhere in the body regardless of age, as in fracture of the external condyle of the humerus and the carpal scaphoid.

12. The blood clot which is essential to early bone regeneration is said to be deficient in this fracture.

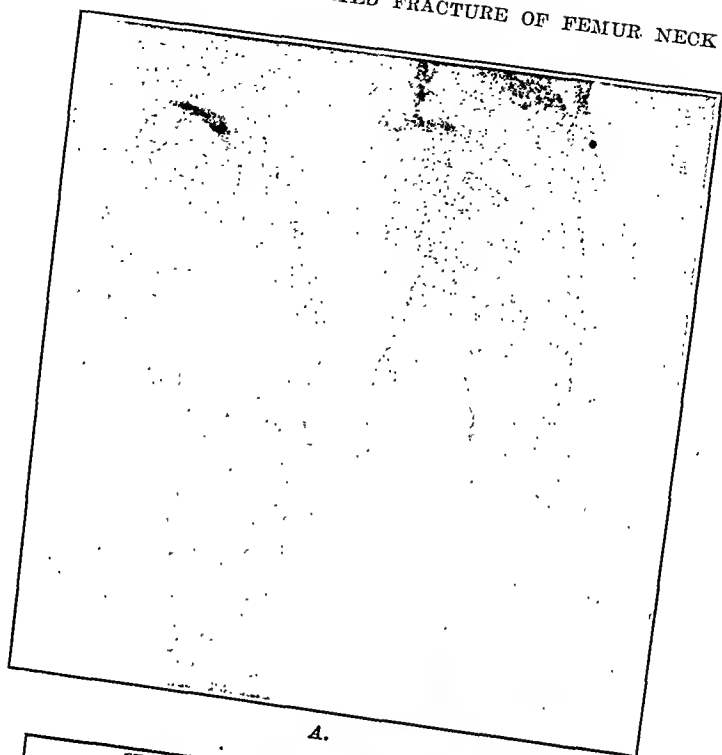


Fig. 6.—Age, forty-nine years. Whitman reconstruction operation. Excellent function.

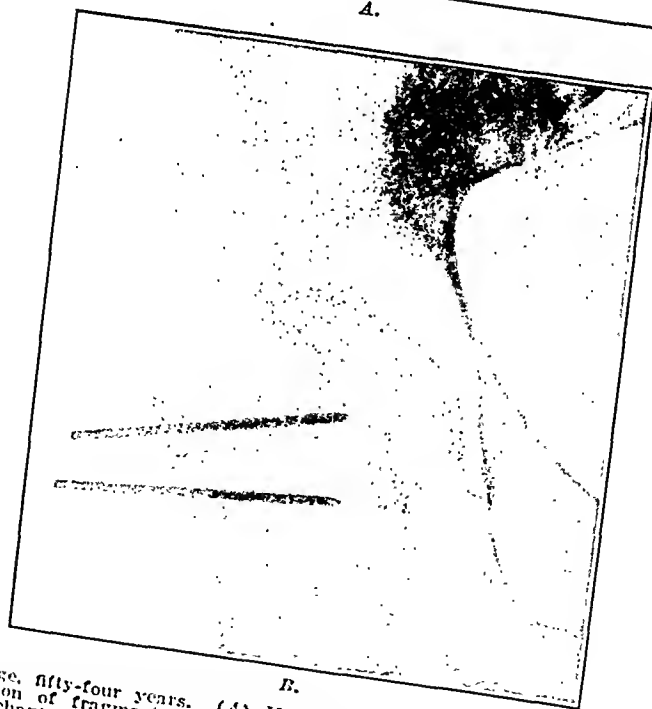
13. The capsule may be torn and caught between the fragments; also, certain muscles could possibly be interposed.

The physiologic reparative process differs from that of other fractures to such a degree that it may be regarded as almost pathologic. This is chiefly in the behavior of the head or proximal fragment. In the opinion of Sir Astley Cooper, the head always becomes necrotic and does not unite by bone. Axhausen and Bonn at the present time also state that the head becomes necrotic. Santos, however, has made an exhaustive investigation as to the reaction of the head which explains more clearly the pathology. We have also examined a number

CAMPBELL: UNUNITED FRACTURE OF FEMUR NECK



A.



B.

FIG. 9.—Age, fifty-four years. (A) Ununited fracture of ten months' duration; wide separation of fragments. (B) Reconstruction operation which consisted of detaching trochanter and transplanting head as a graft to lateral aspect of femur, with restoration of normal fulcrum, and maintaining upper extremity of femur in acetabulum.

regularity in the contour of the head. Microscopic examination of the necrotic head demonstrates the usual characteristics of dead bone, in that the lacunae are empty and the staining quality of the few remaining cells is impaired. Fibrous tissue invades from the fovea, which is probably instigated by the vessels of the ligamentum teres. New bone is formed by this tissue, until the entire head or any portion thereof may be restored to living bone. The articular cartilage dies, undergoes fibrillation, is exfoliated and absorbed. Adhesions form between



Fig. 8.—Age, sixty-two years. End-result of Whitman operation with dislocation. Marked atrophic changes with absorption.

the head and acetabulum, from which there may be further invasion of fibrous tissue which becomes converted into bone.

When the living head unites and function is increased, the structure of the bone is gradually restored to normal in the same manner as the surrounding osseous tissue. When the living head fails to unite, there is gradual atrophy until only a small portion may remain. When the dead head unites, the entire head may be gradually invaded from the fovea and from the distal fragment, or small sequestra may be extruded into the joint. Thus the globular contour of the head may become

A.



B.



FIG. 10.—Age, sixty-six years. (A) Nonunion fracture neck of femur after six months well-leg traction. (B) Six months later, solid union after subtrochanteric osteotomy.

more or less incongruous. When the dead head does not unite, the size becomes diminished by a process of erosion and is usually invaded by new bone until the entire structure is restored, after which the density and appearance are the same as that of the living head and the surrounding living tissue.

Many operative measures have been employed for the relief of this deplorable condition. Before the mechanics were understood, excision of the head was employed with little if any improvement. But as soon as it was recognized that a firm bony support to the upper extremity of the femur was required, better results were attained. Operative measures for this purpose may be enumerated as follows:

1. Bone graft, or so-called "pegging" of the fragments with a large autogenous graft from the tibia.

2. Brackett operation which consists of scooping out the interior of the head of the femur, denuding the distal fragment, and placing it within the excavated head.

3. Albee operation which consists in excising the head and dividing the shaft of the femur longitudinally for several inches, and deflecting the external fragment outward and placing the upper end of the femur within the acetabulum. The head of the bone is placed between the fragments, thus maintaining the trochanter outward, which restores the leverage action of the muscles.

4. The Whitman operation which consists in detaching the greater trochanter with attached abductor muscles and removal of the head of the femur. The upper extremity of the femur is then placed within the acetabulum, and the trochanter is reattached on the external surface of the shaft of the femur several inches below the normal attachment, thus approximating the upper extremity of the shaft to the acetabulum and giving better leverage action to the abductor muscles.

5. Reconstruction operation which consists of detaching trochanter and transplanting remodeled head as a graft to the lateral aspect of the femur, and reattaching the trochanter to this graft by means of a wire nail, restoring the normal fulcrum and maintaining the femur in the acetabulum.

6. Osteotomy of the shaft of the femur at about the level of the lesser trochanter, after which the shaft is displaced inward beneath the head and fracture line. The superior osseous support is thus restored and at the same time the shearing action at the fracture line is eliminated.

7. Osteotomy of the shaft at the level of the tuberosity of the ischium with inward angulation of the fragments (Schantz). After union of the fragments, the femur and extremity is stabilized and supported by the lateral aspect of the pelvis; the shearing action is also eliminated.



B.

Fig. 16.—Age, sixty-six years. (A) Nonunion fracture neck of femur after six months well-leg traction. (B) Six months later, solid union after subtrochanteric osteotomy.

The author and his colleagues have employed all of these procedures with the exception of the last. A review of our private records of seventy-five cases in which operation has been employed for central ununited fracture of the neck of the femur forms the basis of this discussion, the end-results of which may be enumerated by the following table:

The bone graft operation was employed in thirty-six cases, but it is only indicated in those in which the neck of the femur is well preserved, and in consequence is rarely advisable after the lapse of one year. The great disadvantage is the prolonged after-treatment which



A.

Fig. 11.—Age, sixty-one years. (A) Ununited fracture neck of femur, seventeen months' duration. (B) Smith-Petersen nail used; good approximation of fragments. Subtrochanteric osteotomy with beginning union. Patient walking in brace. Apparently good result.

is often required before the roentgenogram will demonstrate bone trabeculae traversing the line of fracture which is the only sign by which osseous union can be determined. This operation is the ideal procedure, as perfect anatomic restoration is possible, but as many elderly individuals cannot stand further prolonged confinement, the procedure is only advisable in selected cases.

I have employed the Brackett and Albee operations in too few cases to warrant an opinion, except to state that I have seen excellent results

with each procedure. The reconstruction was usually employed in those cases in which a long period of time had elapsed, in aged individuals, and in those with extreme absorption and separation of fragments. In approximately 60 per cent, the Whitman reconstruction operation will give excellent results and a fair chance of restoration, or at least a high per cent will be materially improved. Excellent results after this operation are relative, since the condition of the patient is by no means as good as in those cases in which the bone peg

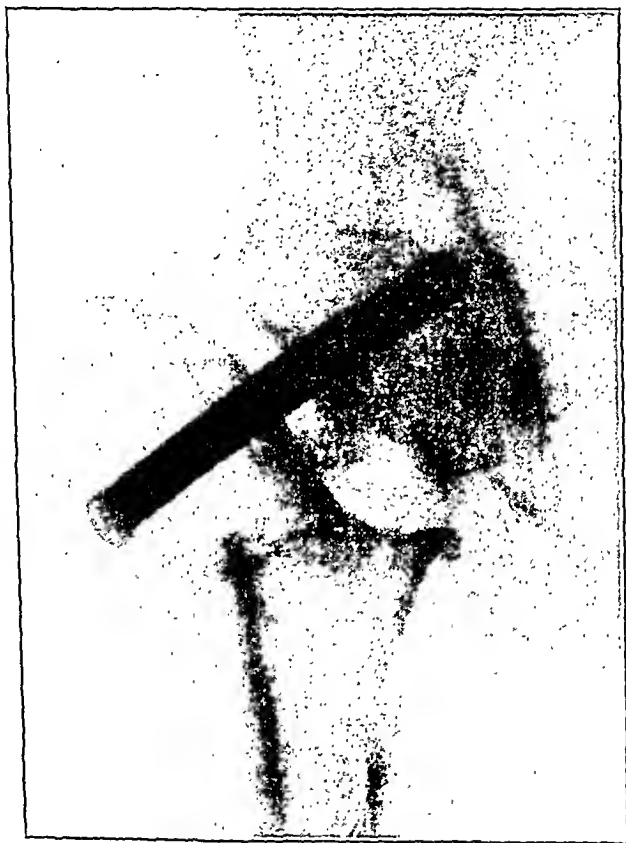


FIG. 11-B.—See opposite page for description.

operation succeeds. Two of the cases continued to use crutches but were relieved of pain and greatly improved; they probably could have walked without support if they had been less apprehensive and more cooperative. The remaining twelve were able to walk with definite limp and were materially improved, much depending on the muscular restoration in the individual case. In two of the Whitman operations, the upper extremity of the femur could not be maintained within the socket and dislocated or subluxated, giving an unstable hip which was

no improvement over the former state. This may have been due to the loss of proper leverage or to weak musculature. In a number of cases, a bony shelf was made from the ilium to deepen the socket and prevent this complication.

The author has employed a technic (No. 5) which consists of detachment of the trochanter, excision of the head, remodeling of the upper extremity of the shaft, and placement of it within the acetabulum. The head of the bone is then denuded of cartilage and made into a



Fig. 12.—Age, seventy-one years. Subtrochanteric osteotomy four months after operation. Too early to determine union, but patient has excellent functional result.

cube which is employed as a graft. An area is next denuded on the external aspect of the shaft below the site of the greater trochanter to which the graft is approximated. The detached trochanter is next brought down and closely approximated to the graft. Two rustless steel nails are now inserted through trochanter, graft, and shaft. The trochanter is thus attached at a lower level, and the transposed head displaces the trochanter outward, thus giving more efficient leverage and holding the upper extremity of the femur within the acetabulum. In other words, a new neck is substituted, giving a more normal me-

chanical status. The procedure combines the principles of Albee and Whitman. In only one case can the result be estimated, and that was excellent.

The osteotomies and plastic procedures are too recent to draw definite conclusions. It is most interesting, however, to note that apparently excellent functional results have been secured in all of these cases by simply eliminating the shearing action at the point of fracture. In one case treated elsewhere by continuous well-leg traction for six months without union, in a debilitated woman sixty-six years of age, osseous union was induced in six months, and the patient has a most excellent result. In three cases, there was extensive absorption of the neck with such a wide separation between the head and neck that a closer approximation was made between the fragments by internal

TABLE I
BONE PEGGING

Solid bony union	20
Failure	8
Unknown or too early	7
Died	1
Total	36
RECONSTRUCTION	
Excellent	14
Failure	8
Unknown	12
Died	1
Total	35
OSTEOTOMIES	
Excellent	1
Too early	3
Total	4

fixation before osteotomy, as above described, was employed, thus possibly enhancing union between the fragments, or at least producing more stability. In one instance, a Smith-Petersen nail was employed for this purpose, and in two cases, bone grafts. In two, the results are excellent, and one is too recent. At the recent Congress of the Internationale Orthopedie Association in Rome, Dr. Faldini, of Milan, demonstrated about twenty cases in which he had employed the low osteotomy in fresh fractures of the neck of the femur, thus supporting the limb by the lateral aspect of the pelvis. The results were excellent and amazing, the patients walking with scarcely a limp.

This type of operation (Nos. 6 and 7) surely adds a new principle and procedure to our armamentarium. The surgical risk is much less and can certainly be employed under less favorable physical condition

than the other more formidable measures, and it is quite possible may, to a large degree, supplant other surgical procedures, not alone in non-union but also to some extent in fresh fractures.

The average decrease in the length of the extremity in the bone graft operation varied from one-fourth to one and one-fourth inches, and in the reconstruction operation from one-half to two inches; however, this is not an element if better function can be secured. By these measures above described, there is reasonable chance of securing a high percentage of function in those in whom no improvement could be expected.

The most important factor that I desire to emphasize is the early recognition of nonunion in this fracture which is present in all cases not reduced under thirty days and in those in which there are late changes in the relation of the fragments. Better results with more muscle power are secured in those which can be operated on before there is extensive osseous atrophy.

In the above survey, many months and often years had elapsed in a majority of the cases before aid was sought. Undoubtedly a much higher percentage of excellent results could have been secured if efficient measures had been instituted earlier.

DISRUPTION OF ABDOMINAL WOUNDS: AN UNSOLVED PROBLEM

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WITHIN the last six months, two patients, on whom I had performed laparotomy through a right rectus approach, suffered disruption of the incision. In neither case was there any evidence of infection of the peritoneal cavity, or of the incision. In one instance, the patient was fat and with a moderate jaundice at operation. She was fifty-eight years old, and cholecystectomy had been done. On the fifth day, there was considerable discharge of bloody serum in the dressings, and, when the wound was examined, there was complete separation of all the layers of the incision, but without any protrusion of abdominal contents. Careful examination of the wound edges from skin to peritoneum failed to discover any catgut, except two knots lying free, and these were in the late stages of disintegration.

The second patient was fifty-one years old, moderately fat, but without jaundice; cholecystectomy had been done. On the seventh postoperative day, there was an abundant discharge of bloody serum in the dressings, but the skin incision was intact, and it was thought that the anterior layer of the rectus sheath was not separated. He had no fever or unusual abdominal discomfort. His abdomen was not distended, he had not been vomiting and was apparently making an uneventful recovery. His abdomen was snugly strapped with adhesive tape, and his convalescence was otherwise a smooth one. Within a few weeks, however, following the upright position, he developed a large hernia, occupying the entire length of the incision.

In each of these patients, the wound was closed with continuous No. 2 chromic gut in the peritoneum and posterior sheath of the rectus, and interrupted No. 2 chromic gut in the anterior sheath, interrupted 00 plain gut to approximate the fat, and fine black silk in the skin.

Hinton suggests that allergy may be the "explanation of wound dehiscence and incisional hernia," and he used solutions of fresh sheep-gut in intradermal injections on 112 patients. Nine of these patients showed a moderate local reaction.

Babcock reported a number of experiments in which the local reaction of human tissues to different suture materials was observed and stated

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that both plain and chromic catgut gave a uniform, but varying local reaction, when imbedded in the skin. He called attention to the disappearance of catgut in disrupted wounds.

Disruption of the abdominal incision is a serious postoperative mishap. In 1933, a symposium was held on this subject by the New York Surgical Society; as a result of that discussion, a number of excellent papers are in the literature. The following statement is from Hinton's recent paper:

"Papers were read by members of the staffs of five hospitals in New York, and Meloney and Howes reported 55 cases from the Presbyterian Hospital in an eight-year period, or an incidence of 1 per cent. They thought that the diagnosis had been frequently omitted from the records if there had not been a secondary closure and that 2 per cent would more nearly represent the incidence of this 'catastrophe.' Colp reported 29 cases in 2,750 laparotomies, or an incidence of 0.9 per cent, from the Mount Sinai Hospital. Grace reported 44 cases in a fifteen-year period from the first surgical division of the Bellevue Hospital. White reported 30 cases from the Roosevelt Hospital. Heyd reported 4 cases in 1,000 laparotomies performed at the New York Post-Graduate Hospital in 1932 and 4 personal cases. There was a total of 166 cases reported at the meeting of the New York Surgical Society. Sokolov in 1931 reported the largest group of cases on record, numbering 725, based on the experience of 187 surgeons. He sent questionnaires to 1,140 European surgeons. Eliason and McLaughlin reviewed 9,155 operations at the University of Pennsylvania Hospital and found 25 instances of dehiscence. Maes, Boyce and McFetridge reported 44 cases in a ten-year period at the Charity Hospital in New Orleans. Baldwin reviewed his individual series and found that in the past thirty-five years he had not had a single instance of dehiscence in 16,465 operations. After one studies these reports as to the cause, prevention and treatment of this serious sequela of celiotomy, it is difficult to evaluate the opinions expressed by the different authors."

When I first began operating, I followed the practice of most Baltimore surgeons of that period and closed the abdomen with fine silk from peritoneum to skin, using, in the main, interrupted sutures. This method has a number of objections. It is slow and tedious, and fine silk is relatively difficult to handle. It breaks easily if too much tension is put on it, especially if the second knot is snapped down too sharply. The greatest objection to it comes from its behavior in infected wounds. Then, there is the prejudice against leaving foreign material in the tissues. Another objection to silk has to do with the preoperative technique. If silk is wrapped tightly on the spool, routine boiling will not completely sterilize it, and a low grade localized infection may develop some weeks subsequent to operation. The first and last objections may be overcome by proper care. Because of the above factors, and in con-

sequence of the great improvement in the manufacture of catgut, I followed the general trend and began the use of gut. I often made the mistake of using larger catgut than was necessary and did not realize that a suture need not have any greater tensile strength than the structures that it approximates, provided the suture continues to function until union is secure.

During my service in a base hospital in this country in 1917, I did a great many hernioplasties using chromic catgut. These patients were all young. Most of them were thin and in excellent physical condition and were, of course, fine operative risks. We did not have any means of following them up; the operative results seemed satisfactory. Following the war, for a period of about two years, I used catgut in all hernioplasties and soon began to notice an increased percentage of recurrence; since 1922, I have used silk, linen, or fascia. About this time I began to close the abdomen, except the McBurney approach, by a combined method, safeguarding the use of catgut by interrupted sutures of heavy, soft white silk including all layers of the abdomen, except the peritoneum. This is a satisfactory method in my experience, except in fat persons in whom the interrupted silk sutures have a tendency to cut through if tied snugly and are apparently of little benefit if tied loosely.

Since the two mishaps mentioned in the beginning of this paper, I have closed the peritoneum with fine, chromic gut, and the remainder of the incision with fine silk. I am writing this personal experience of vacillation and anxiety, because it is a fairly accurate picture of what has been occurring in the minds and experience of many surgeons.

There is abundant evidence in the literature that behavior of abdominal incisions has been the cause of much uncertainty and perturbation. The reports fall in two groups. In one, research and investigation have been carried on to determine just what happens in a wound undergoing repair, and to observe how these changes are modified by chemical and physical agents. Harvey and Carrel especially have been interested in this phase of the problem. In the other group are found many clinical reports of dehiscence of the sutured abdominal wall.

Two distinct conditions are found in incisions that fail to unite promptly. In infected wounds the etiology and pathology are understood. Serious infection of the abdominal incision will interfere with the normal processes of healing and may be followed early by rupture of the wound or later by herniation. The infection may be an extension from the abdomen, or a wound infection confined largely to the abdominal wall. Usually the former condition exists. In severe infections, it matters very little what method of closure is used, so far as the tendency to disruption is concerned. If gross rupture does not occur, a surprisingly good repair of the abdominal wall may be obtained, provided the patient escapes the risks of the infection.

There is another group, however, in which observation and investigation prove that wound infection does not play the major part, and other factors must be considered. But, in the meantime, hundreds of laparotomies are being performed daily, and the possibility of disruption of the wound creates a risk to the patient and a state of anxiety in the mind of the surgeon.

Dehiscence of the incision is followed by a death rate that is very disturbing. It is often difficult to separate the two groups in estimating the mortality reported in the literature. Much of it is due to infection, and the underlying peritonitis is chiefly at fault. In this group the mortality is very high. In those patients where infection is not present, and where the condition is recognized promptly and reoperation immediately performed, the death rate is lower. In the *Annals of Surgery* for September, 1925, the writer reported five such secondary closures without mortality.

In the combined group, however, the mortality is appalling. "Meleney and Howes found a mortality of 44 per cent, Colp of 28 per cent, Grace of 39 per cent, and Sokolov of 33 per cent. The mortality in the cases reported in this paper was 16.7 per cent. When the three fatalities are reviewed (Cases 13, 17 and 18) it can be seen that the primary cause of death was diffuse peritonitis. The uncomplicated cases of dehiscence of the wound rarely cause death if one is constantly watching for the first signs of this tragedy" (Hinton). The next sentence in Dr. Hinton's paper immediately following the above quotation is very striking—"Dehiscence of the wound has caused me more consternation than any other sequela of abdominal operation."

Surgeons, therefore, are faced by a very real problem. What can be done to lessen the percentage of broken-down, uninfected abdominal incisions? There are many reports on the healing of wounds. Most surgeons believe that clean wounds heal without any local aid, that wounds heal best when least disturbed by trauma or chemicals, and that the suture material should possess adequacy with the minimum of bulk and irritation.

There are a number of anatomical considerations. The abdominal wall is attached to the costal margin, to the lumbar vertebrae, and to the pelvis. When the patient is lying in the recumbent position, the spine and pelvis are relatively fixed and still, but the costal margin is moving constantly, and with each inspiration, there is a lateral pull on the two sides of the abdomen tending to increase the tension on the suture line. The nearer the incision is to the rib margin, the greater the degree of pull. The blood and nerve supply are important factors also. Thin fascia and poorly developed muscle enter into the problem, and fat is a lubricant that interferes with healing, especially if it is allowed to thrust itself between the wound edges.

A very important thing is the transverse direction of the deeper layers of the abdominal wall giving poor support to the suture line of a vertical incision. Pool, in 1931, reported a method of closure with this fact in mind. One of the advantages of the transverse upper abdominal approach is a more secure suture line. Lynn and others have called attention to this.

There has been a widespread belief in a number of factors outside the wound itself that hasten or retard union. Among these are kinds of food, dehydration, infection in other parts of the body, especially in the chest, liver dysfunction, kidney damage, age, starvation, vitamins, endocrine activity, abdominal distention, vomiting, etc. Conflicting statements are made by different observers, and there is considerable confusion, but evidence seems to be accumulating that, in addition to the above-mentioned causes, there occurs in certain incisions an undetermined type of wound reaction in which the usual processes of healing are interfered with; and there is a distinct group in which infection, as we understand it, plays little or no part.

There are two conditions, however, about which there is no question as to their ill effects upon wounds—blood supply and diabetes. It is an axiom as old as modern surgery that diabetes should be brought under the best control possible and kept there during the period of wound healing, and that both the general and local circulation should be safeguarded.

There are four important steps in performing an abdominal operation. The first has to do with preparation of the patient, of the dressings, the instruments, the training of nurses and assistants, etc. The second is the operative approach. It is known, of course, that some incisions give less trouble than others. The third is the operation itself, which should be done gently, neatly, and thoroughly, having in mind immediate results, postoperative adhesions, and intestinal obstruction. These things are so well known that to repeat them is to be tiresome. The final step is the one about which there is lack of agreement, much anxiety, and no little grief—the method of closure. Many different materials are used. No single way of suturing the wound edges has been proved uniformly satisfactory. The problem calls urgently for solution.

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POSTOPERATIVE WOUND SEPARATION: REVIEW OF CASES

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THE discussion on postoperative wound rupture at a recent meeting of the New York Surgical Society has stimulated renewed interest in this condition as indicated by the number of subsequent papers. It is fully realized that inferences drawn from a small series such as this may be misleading, but at the same time it is hoped that the presentation of this review will be a contribution to the general statistical studies on the subject.

Postoperative wound rupture occurred in 50 of 7,903 consecutive laparotomies performed at the Henry Ford Hospital, an incidence of 0.64 per cent.

Inguinal and femoral herniotomies, strictly speaking, are laparotomies, but they are not included in this compilation. The above figure is not a true index of the frequency of this condition. The actual percentage of occurrence can be arrived at only by including those cases which leave the hospital with their wounds in an apparently satisfactory condition, but who subsequently develop postoperative ventral hernias. In the latter group, some degree of wound separation, varying all the way from the protrusion of a small tag of omentum through the peritoneum and posterior rectus sheath, to the disruption of all the layers of the abdominal wall except the skin, must have occurred during the immediate postoperative state. That this condition should pass unnoticed is not surprising when it is considered that the majority of cases of complete disruption are not recognized or even suspected until the skin gives away, and a viscus protrudes.

It is our practice to perform immediately secondary closure on all cases. This is possible even in very sick patients, if they are moved to the operating room and operated on in their own beds. The use of local novocaine infiltration plus subcostal block provides adequate relaxation if general or spinal anesthetic is contraindicated by the patient's condition. In this series, 49 of the 50 cases, or 98 per cent, had a secondary closure done.

The one patient on whom operation was not done was believed moribund at the time wound rupture occurred. Conservative treatment of the wound by covering the protruding viscus with sterile

gauze and strapping the wound edges together with flamed adhesive resulted in recovery, but with the formation of a very large postoperative ventral hernia. Only the 49 patients on whom operation was done are considered in this review.

AGE GROUP BY DECADES

TABLE I

DECADE	NO. PATIENTS	DECADE	NO. PATIENTS
1. 0-9	0	5. 40-49	13
2. 10-19	2	6. 50-59	10
3. 20-29	6	7. 60-69	3
4. 30-39	14	8. 70-79	1
	22		27 Total, 49

The ages ranged from 14 to 72 years, the average age being 43.3 years. Over 75 per cent of the patients were in the fourth, fifth, and sixth decades, i.e., between the ages of 30 and 60 years, the period of life when individuals are most likely to be subjected to operations. Thus age alone does not appear to have a bearing on this condition.

SEX

TABLE II

Males	27	55%
Females	22	45%

Table II shows a slight preponderance of males, but not enough to be significant.

SEASONAL OCCURRENCE

TABLE III

WINTER		SPRING		SUMMER		FALL	
December	3	March	9	June	2	September	5
January	4	April	7	July	1	October	4
February	4	May	4	August	2	November	4
Total	11—22%		20—10%		5—10%		13—25%

Sokolov, of Leningrad, reports that in Russia the majority of wound ruptures take place during the winter. His explanation is that during this season, the abdominal musculature is not so well developed owing to inactivity and a tendency to food deficiency. A study of Table III shows that almost as many wound ruptures occurred in spring as in autumn and winter combined, and that the incidence in spring was four times the summer rate. This is very suggestive of the importance of respiratory diseases as a causative factor.

INCISIONS

TABLE IV

UPPER ABDOMINAL		LOWER ABDOMINAL	
Paramedian	16	Paramedian	23
Linea alba	6	Rectus splitting	0
Linea alba and T-extension	3	Pfannenstiel	0
Rectus splitting	1	McBurney	0
Total	26—53%	Total	23—47%

In upper abdominal incisions, there were 26 ruptures, or 53 per cent of the total, and in the lower abdominal incisions 23 ruptures, or 47 per cent of the total. The difference here is so slight as to appear insignificant. These figures closely approach the findings of Sokolov, who reviewed 730 cases and reported 57 per cent occurring above and 43 per cent below the umbilicus.

In this clinic, the paramedian incision with reflection of the rectus muscle outward is employed in biliary tract surgery, and incision through the linea alba is used for gastroduodenal operations. Though the former incision is utilized much more frequently, the latter has definite advantages when speed is indicated, since the abdominal cavity is entered directly through an avascular area. Another point in its favor is that none of the tissue planes are entered, thus safeguarding against loss of tissue should wound infection supervene. Healing of the structures of the linea alba is often delayed as a result of the poor blood supply in this area. Some of the difficulty may be overcome by imbricating the layers, a maneuver easy to carry out in cases requiring stomach and duodenal operations, since there is usually an associated weight loss. The poor repute which this incision bears is not enhanced by reference to Table IV where it is found that 9 of the 26 upper abdominal ruptures, or 34.6 per cent, occurred in sections through the linea alba. In splenectomy, the T-shaped incision, vertically through the linea alba and transversely across the left rectus muscle, is frequently utilized because it gives an excellent exposure of the splenic pedicle. The rectus muscle is seldom split, because of the inevitable loss of tone of the medial fibers, an objection which may have more theoretical than practical value. The transverse and the subcostal incisions of Kocher have been employed with satisfactory results, but so infrequently that their value cannot be estimated.

In the lower abdomen, the so-called right rectus incision with reflection of the rectus muscle fibers outward is the incision of choice for pelvic surgery and appendicitis operations when abdominal exploration is indicated. The McBurney incision for acute appendicitis is favored here because of the excellent results obtained. The approach to the appendix is more direct than that afforded by the right rectus incision, thereby minimizing soiling of the peritoneal cavity in

infected cases. Further, when drainage is necessary, the drainage tube can be placed so as to be largely extraperitoneal, while that part within the peritoneal cavity is placed, not through a coil of intestine, but down along the parietal peritoneum, thus lessening the number of peritoneal adhesions and postoperative obstructions. Another reason for the use of the McBurney incision is the fact that the recurrence of both postoperative wound ruptures and postoperative hernias, even in infected cases, is so small as to be almost negligible. The objection of insufficient exposure may be invalidated if the Weir extension is employed. The wisdom of this choice is emphasized by the fact that none of the McBurney incisions broke open during the postoperative state. The split rectus and Pfannenstiel incisions are infrequently used.

DURATION OF OPERATIONS

TABLE V

DURATION	NO. PATIENTS	DURATION	NO. PATIENTS
$\frac{1}{2}$ hour	1	$1\frac{1}{2}$ hours	6
$\frac{3}{4}$ hour	7	$1\frac{3}{4}$ hours	5
1 hour	12	2 hours	14
$1\frac{1}{2}$ hours	2	2 hours, plus	2
Total	22—45%		27—55%

Table V shows that postoperative wound rupture occurs even after short operations. In 20 cases, or nearly 40 per cent, the operating time was not longer than an hour. Assuming that the operator is skilled, the time consumed in performing an operation is a rough index of its severity or at least of the difficulties encountered. In this series, the time factor appears to exert a definite influence on the condition under discussion, since in 55 per cent of the cases, the operations lasted one and one-half hours or more, and the average operating time was one and one-quarter hours.

MULTIPLE OPERATIONS

TABLE VI

	NO. OF CASES	PERCENTAGE
Single operations	13	26.5
Multiple operations	36	73.5

The performance of more than one operative procedure at a time has an undoubted bearing on the increase of postoperative wound rupture. This is attested by the fact that in this series, 36 of the 49 patients, or 73.5 per cent, were subjected to multiple operations. In some instances, this additional work consisted only of removal of the appendix. When more than one procedure is carried out, the operat-

ing time is prolonged and trauma increased, since it is frequently necessary to enlarge the incision or institute vigorous retraction in order to obtain adequate exposure.

CLASSIFICATION OF OPERATIONS

TABLE VII

			PERCENTAGE	
<hr/>				
PELVIC				
Nonmalignant	12			
Malignant	2			
	<hr/>			
Total		14	28.6	
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GALLBLADDER				
Cholecystectomy alone	2			
Cholecystectomy with appendectomy	7			
Cholecystectomy with drainage pancreas	1			
	<hr/>			
Total		10	20.4	
APPENDECTOMY, Right rectus		8	16.3	
GASTRODUODENAL				
Malignant	4			
Nonmalignant	3			
	<hr/>			
Total		7	14.3	
SPLENECTOMY		4	8.2	
ABDOMINAL EXPLORATION in Cirrhosis of Liver with Ascites		3	6.1	
CARCINOMA COLON		2	4.1	
UMBILICAL HERNIA		1	2.0	
<hr/>				
Total		49		

Worthy of note are the comparatively few carcinoma cases whose wounds disrupted, only 8, or 16.3 per cent. of the series. This figure is low compared with 28 per cent reported by Colp, and 40 per cent reported by Stair and Nelson. The high increase of ruptures in cases of ascites is in agreement with other observers. The relatively large numbers of wound separations following splenectomy must be considered as an indictment of the use of the T-shaped incision. The eight cases of disruption after right rectus appendectomies in a small series compares favorably with a larger group of McBurney appendectomies without a single instance of wound rupture.

METHOD OF SUTURING

Our routine closure of abdominal wounds, except in clean cases in which silk is used, is done with continuous No. 1 plain catgut for the posterior rectus sheath and the peritoneum, and interrupted figure-of-eight No. 1 chromic catgut sutures for the anterior rectus sheath. The subcutaneous tissues are closed with interrupted sutures of No. 1 plain catgut, and the skin margins are brought together with interrupted sutures of fine black silk. This procedure was carried out in

all but two cases of this series, when No. 1 chromic catgut was substituted for No. 1 plain catgut in the suture of the posterior rectus sheath and the peritoneum.

In certain clean cases, all layers are sutured with silk. It is interesting to note that there were no cases of wound disruption in which silk was used. Unfortunately, the total number of cases in which silk was used is not available for discussion at this time so that no deduction can be drawn. In consideration of the relative merits of these suture materials, it should be noted that silk is used only in the most favorable cases. It is evident that care in suturing is of more importance than the suture material used. A meticulous approximation of the peritoneum and posterior rectus sheath so as to prevent the insinuation of omental tags is the first requisite for a solid wound. When wound rupture occurs, however, from no other apparent reason than disintegration of catgut, the suggestion that the use of silk sutures might have avoided the catastrophe is bound to arise. Coaptation of the wound edges should be the objective, but strangulation of the tissues by tight suturing must be avoided.

STAY SUTURES

TABLE VIII

	TOTAL NO. CASES	NO. CASES STAY SUTURES	PERCENTAGE
<i>Upper abdomen</i>	26	13	50.0
<i>Lower abdomen</i>	23	5	22.0
	49	18	36.5

Stay sutures were used in 36.5 per cent of the series. They were made use of in 50 per cent of upper abdominal and in 22 per cent of lower abdominal incisions. These findings are in accordance with the procedure at this hospital where stay sutures of silkworm-gut are used in upper and lower abdominal incisions in about the above ratio. These sutures are inserted through the skin, subcutaneous structures, and anterior rectus sheath only. The value of stay sutures used in this manner is problematical. Adequate support can be given only when stay sutures are inserted through all the layers of the abdominal wall, including the peritoneum and posterior rectus sheath. This procedure, however, has the theoretical disadvantage of acting as a possible source of contamination to the peritoneal cavity when the sutures are removed, owing to the frequency with which the so-called stitch abscess forms around the stay sutures. For this reason, most surgeons are content to include only the anterior rectus sheath, or at most only the muscle and its sheath. Kennedy is the great proponent of the through-and-through stay suture. His results are so excellent that the method warrants consideration. When postoperative dis-

ruption of a wound does occur, stay sutures play an important part in preventing evisceration and in minimizing exposure of the abdominal contents. This benefit alone merits the continuance of their use, even if they have no value in preventing the accident.

DRAINAGE

Peritoneal drainage was established by deep drains in 19, or 38.5 per cent, of the cases. In all but two instances, or in 95 per cent, the drains were brought out through the original incision. This raises the question of the value of stab drains, which, theoretically at least, ought to be preferable to drains placed in the suture line. The decision as to the drainage site should be decided by the directness of approach to the infected area. A drainage tube through the suture line going directly down to the region requiring its use has obvious advantages over oblique drainages through a stab wound. As for example, drainage of the common duct is better through a paramedian incision than through a stab wound at the outer border of the rectus muscle. On the other hand, better drainage of the pelvis can be obtained by introducing the drain through a suprapubic stab wound or through the posterior fornix, rather than through a McBurney incision.

POSTOPERATIVE COURSE

TABLE IX

COMPLICATION	NO. OF CASES	PERCENTAGE
Distention	28	57.0
Coughing and sneezing	22	45.0
Bronchopneumonia	9	
Bronchitis	4	
Lobar pneumonia	1	
Atelectasis	1	
Wound infection	10	20.0

The postoperative course of the patient whose wound ruptures is seldom uncomplicated. Even in those cases where rupture occurs without apparent warning, a review of the hospital records will show that the temperature and pulse remained elevated beyond the normal reaction period, but not enough to excite suspicion that all was not well. Vomiting when it does occur is frequently evidence of separation of the peritoneum and posterior rectus sheath, and is occasioned by the accompanying partial intestinal obstruction. Thus, it is an effect rather than a cause. The importance of respiratory complications as a factor is emphasized in Table VIII. Here it is shown that coughing and sneezing were recorded as a postoperative complication in 22 patients, or 45 per cent of the total number. Of these patients, 9 had bronchopneumonia; 4, bronchitis; 1, lobar pneumonia; and 1, atelectasis. Distention was pronounced in 28 cases, or 57 per cent,

but it is such a common postoperative complication that its rôle as a causative agent is difficult to evaluate. Gross wound infection, either primary or secondary to intraabdominal contamination, was observed in 10 cases, or 20 per cent, and in all instances was associated with sloughing of the anterior rectus sheath.

DAY OF POSTOPERATIVE WOUND SEPARATION

TABLE X

DAY	NO. OF PATIENTS	PERCENTAGE
6	10	20.0
7	11	22.5
8	11	22.5
9	6	12.0
—	—	77.0
	38	
4th, 5th, 12th, and 13th days	2 each	
2nd, 11th, and 14th days	1 each	

The earliest postoperative wound separation was observed on the second day following operation, and the longest interval between operation and disruption was 14 days. The average was 7.6 days. About an equal number of ruptures took place on the sixth, seventh, and eighth postoperative days. If the ninth day is included in this group, a total of 38 cases, or 77.5 per cent of the cases, occurred in this four-day period. Only 5 cases, or 10 per cent, happened before the sixth day, and only 6 cases, or 12 per cent, after the ninth day. The above figures must indicate only the approximate time the peritoneum and posterior rectus sheath give away. They actually designate the day on which separation of the skin edges and evisceration take place.

CLINICAL FEATURES

The absence of shock when rupture takes place is noteworthy. In fact, it is not uncommon for the patients to state that they feel relieved when the wound margins separate. The paucity of signs may be attributed in part to the gradual onset of the condition, and in part to the fact that it may be masked by other complications. Frequently the first evidence of disruption appears on the same day as the skin sutures are removed from an apparently healthy wound. The appearance of a considerable amount of blood-stained serum on the dressings of a wound previously dry is pathognomonic of rupture. On inspection of the wound, a degree of separation is observed varying all the way from the appearance of a portion of omentum at one angle of the wound, to complete separation of the wound margins and partial evisceration.

Postoperative wound ruptures associated with frank wound infection presents a different picture. Here the dramatic onset of the

apparently clean case is lacking, and there is, instead, a more gradual onset. In a typical case, the infection attacks the subcutaneous tissues where it forms an abscess which drains through the skin incision. If the infection is progressive, sloughing of the anterior rectus sheath occurs, followed by separation of the deep layers.

The primary causative factor in the group where there are no signs of gross infection is not clear. The secondary factors, such as inaccurate suturing, faulty suture material, poor physical condition, coughing, distention, etc., must be present in large numbers of patients whose wounds proceed to complete and satisfactory healing. Infection without gross evidence undoubtedly accounts for some cases, but there is still a group where a satisfactory explanation is wanting. The operative findings at the secondary closure are interesting. There are three outstanding features: disappearance of catgut, edema of the abdominal wall, and lateral retraction of the posterior rectus sheath and peritoneum. As early as the sixth postoperative day, it is surprising to find that even twenty-day chromic sutures have entirely disappeared or are represented by only a few frayed strands. The edema of the wound is out of proportion to that which occurs in connection with the inflammatory reaction incidental to normal healing. On palpation, the wound edges have a hard rubbery consistency. This swelling of the wound margins considered in conjunction with the free outpouring of serum at the time of the rupture indicates an excessive tissue response. The whole picture is that of an inflammatory reaction characterized by excessive edema and undue outpouring of serum. This phenomenon suggests an allergic reaction. That infection is not always present is attested by the fact that in some cases primary healing takes place after secondary closure.

CAUSE OF RUPTURE

TABLE XI

IMPRESSION OF SURGEON PERFORMING SECONDARY CLOSURE

	NO. CASES	PERCENTAGE
Coughing	11	27.5
Vomiting	8	20.0
Infection	8	20.0
Getting out of bed too soon	3	7.5
Poor physical condition	3	7.5
Peritonitis	2	5.0
Omental wedge	2	5.0
Poor structures	1	2.5
Faulty catgut	1	2.5
Broken stay sutures	1	2.5
Total	40	—
Unrecorded	9	—
Total	49	—

In 40 of the 49 cases, the surgeon performing the secondary operation recorded his impression of the cause of the catastrophe. Heading the list is coughing in 11 cases, or 27.5 per cent, an observation which again brings attention to the rôle played by respiratory infections. Gross wound infection was noted in 8 cases, or 20 per cent, and in only 5 per cent of the patients was there evidence of peritonitis. The plastic exudate incidental to peritoneal infection causes the viscera and omentum to become adherent, thereby lessening the tendency to evisceration. It is surprising, in view of current opinion to the contrary, that poor physical condition was considered responsible in only 3 cases, or 7.5 per cent. The blood Wassermann reaction was negative in all of the patients.

THE SECONDARY CLOSURE

TABLE XII

SUTURE MATERIAL	NO. CASES	PERCENTAGE
Silver wire alone	34	70.0
Catgut alone	1	2.0
Catgut plus silver wire	14	28.0
Total silver wire	48	98.0
Total catgut	16	30.0

Through-and-through sutures of silver wire were used to bring wound edges together in 70 per cent of the cases. In only 15 patients, or 30 per cent, was it possible to attempt layer closure of the abdominal wall with catgut, and in all but one case, additional reinforcement with through-and-through sutures of silver wire was necessary. Lateral retraction of the posterior rectus sheath and peritoneum prevents satisfactory closure. Only rarely is it possible to attempt separate suture of this structure owing to its friability. This observation that post-operative ventral hernia after secondary closure is the rule rather than the exception serves to draw attention to the important part played by the posterior rectus sheath in maintaining the integrity of the abdominal wall.

MORTALITY

TABLE XIII

DURATION OF LIFE AFTER SECONDARY CLOSURE	NO. CASES
1-24 hours	12
3 days	1
5 days	2
14 days	1
22 days	1
Total	17-34%

There were 17 deaths out of the 49 patients on whom secondary closure was done. This gives a mortality rate of 34 per cent.

It is instructive to note that in 12 of the 17 patients, or 70 per cent, death took place within 24 hours of the secondary closure. This may be taken as an indication of the general condition of the patient at the time of secondary closure. It also serves to substantiate the impression that the real cause of wound rupture lies more in the pathologic condition requiring surgical interference and in the individual's reaction to the operation and its complications, than in faulty methods of suturing. At the same time, this high mortality occurring within twenty-four hours of performing secondary closure brings up the question of the advisability of suturing all cases of wound disruption immediately, unless obstruction is present.

CAUSE OF DEATH

TABLE XIV

Ileus	6	Myocardial insufficiency	2
Peritonitis	4	Pulmonary embolism	2
Pneumonia	4	Pancreatitis	1

Except for the patient with pancreatitis, the cause of death was attributed to complications developing during the postoperative course. It must be admitted, however, that certain of these patients might have recovered had their wounds not broken down.

SUMMARY

1. The incidence of postoperative wound separation in 7,903 consecutive laparotomies was 0.64 per cent.
2. Of the 50 cases, 49 had secondary closures.
3. A seasonal variation is shown in our series.
4. Multiple operations had been performed in 73.5 per cent of the cases.
5. In 55 per cent of the cases, the operation had lasted one and one-half hours, or longer.
6. Stay sutures of silkworm-gut or silver wire were used in 36.5 per cent.
7. The clinical picture in the noninfective cases suggests an allergic reaction.
8. The mortality following secondary closure was 34 per cent.

The author wishes to acknowledge with appreciation the assistance given by Dr. W. D. Thompson in the preparation of this material.

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THE APPLICATIONS OF CAVITY GRAFTING

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THE most important basic principle in the reconstructive surgery of superficial skin defects is the diagnosis of the amount of epithelium lost and its successful replacement by a covering which can adapt itself to its new surroundings as far as possible, anatomically, functionally, and esthetically. With superficial lesions, such as burns, contractures, industrial accidents, congenital deformities, and so forth, this has long been done satisfactorily in a variety of ways, the particular method used depending largely upon the type of lesion, the expected cosmetic result, and the experience of the particular surgeon. The simplest method is undoubtedly by means of a free skin graft cut with a razor and applied under pressure directly to the denuded area after suitable excision of granulomatous tissue and scar. If the graft is well cut, the correct pressure applied to it, and the ordinary surgical principles of strict asepsis and hemostasis enforced, a complete take results in such a very high percentage of cases that one can only be impressed with the essential vitality of epithelium under what are sometimes very adverse surroundings.

Not all superficial defects, however, are confined to the external surface of the body. Many of them involve body cavities, such as the mouth, nose, orbit, or ear, with loss of lining skin and mucous membrane, and present problems of replacement crucial to the success of any repair. This was the type of injury which during the war offered grave difficulties to reconstructive surgeons until Esser showed how free skin could be successfully grafted as a lining membrane into the mouth, where it would endure without harm to itself under conditions normally quite foreign to it. By introducing from below the chin a block of moldable material covered with Thiersch graft, and completely burying it in the subcutaneous tissues, he was able to produce a satisfactory skin-lined cavity which when opened into from above reproduced a destroyed buccal sulcus very satisfactorily. This revolutionary idea was immediately seized upon by Gillies, who with his associates at Sidecup developed what is now known as the "Epithelial Inlay."

The essential modification of the Esser method consisted in the introduction of the skin graft directly into the mouth, where it was

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thus be easily released (Fig. 1). The most frequent field for intra-buccal grafting after injury, however, follows the larger bone grafts to the fractured lower jaw. Side-to-side apposition of the bone graft obliterates the sulcus for such a distance that a stable denture cannot be fitted. Deepening of the sulcus obviates the difficulty and at the same time allows the so-called "flat angle" to be built out to a pleasing contour by an extension on the dental plate (Fig. 2).

3. Occasionally after extraction of teeth in elderly people so much bony absorption takes place in the lower alveolus that the buccal sulcus is too shallow to fit a stable denture. A buccal inlay gives the necessary purchase for satisfactory mastication (Fig. 3).

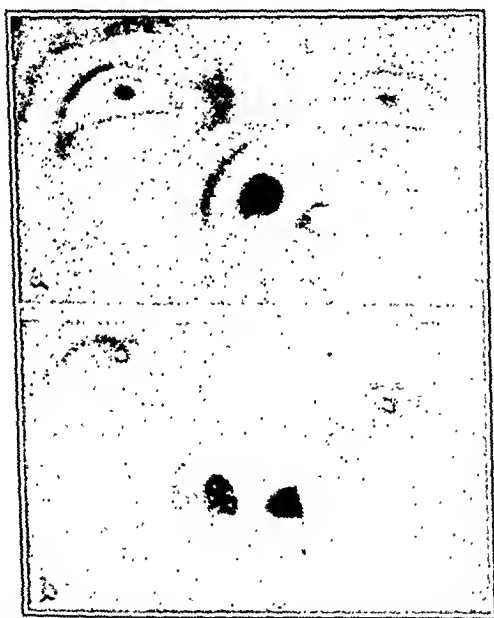


FIG. 1.—Inlay graft behind the upper lip and left ala, freeing them from attachments to the maxillary alveolus and floor of nose. Result of trauma. *a*, Original condition; *b*, after inlay.

4. The repair of congenital deformities, however, affords the most fruitful field for cavity grafting, particularly in secondary cleft lip and palate and in retrognathism.

In primary operations for cleft palate, it is not often used, though at the suggestion of Sir Harold Gillies, I have grafted the extensive lateral relaxation incisions of the Veau technic, which during the healing process must cause considerable contraction and shortening of the united palate.

In most patients in whom secondary operations for cleft lip are necessary, the upper buccal sulcus must be deepened in order to free the short, tight, adherent, and retracted upper lip, and to bring it forward in apposition with the lower lip. This compensates for the

found to take in an apparently septic cavity and in the presence of salivary secretion. The method has now an increasingly wide application in the reparative surgery of civil life, and in this communication I propose to show some results obtained by it, and to demonstrate its use in some unusual situations.

PRINCIPLES OF CAVITY GRAFTING

Wherever it is necessary to construct a new subcutaneous skin-lined cavity or to reconstruct one which has been destroyed, certain precautions must be observed if the finished product is to endure without subsequent contraction. The subcutaneous cavity must be made somewhat larger than the ultimate size required; it must be overdistended with a block of modeling compound accurately molded to the size of the cavity; the mold must be entirely covered by a one-piece Thiersch graft so that a complete take can be expected without breaks in continuity, and with as few epidermal appendages as possible; the cavity must be maintained distended by the original mold for a period well beyond the normal contractile phase of grafted skin. It is most important that this overdistention be carried out for a period varying from six weeks to four months, otherwise even in the presence of a perfect take, serious contraction will occur. Ill effects do not follow if a mold is buried under such conditions for long periods, provided some small drain hole is left for the escape of secretions during the healing phase.

THE MOUTH

This represents the most important field for cavity grafting. The conditions in which an epithelial inlay is required in the mouth are many and various, and may be the result of disease, injury, or congenital deformity.

1. Destruction of the buccal sulci due to disease is usually the result of specific or tuberculous ulceration, particularly that due to lupus vulgaris. In both instances the adhesions can be separated and a mobile lip achieved by the introduction of new skin between the lip and the maxilla. On several occasions I have removed and grafted with good results actively ulcerating patches of lupus upon the hard palate and buccal sulci, where other methods of treatment failed. Experience has shown that lupus rarely invades a skin graft even where the removed patch was in a very active condition.

2. Injuries may also cause loss of buccal epithelium with resultant external deformity which can be cured only when the internal adhesions are freed. As a rule this can be done by adjustment of mucous membrane flaps, but extensive losses will require grafting. The alar base tightly adherent to the anterior surface of the upper alveolus can



FIG. 2.—(See opposite page for legend.)



Fig. 2.—Inlay graft to lower buccal sulcus, following extensive bone graft for osteomyelitis of jaw. This enabled a stable plate to be fitted and the contour of the jaw improved. *a* and *b*, Original condition showing maloccluded and retroposed lower jaw; *c* and *d*, condition after iliac bone graft and inlay for fitting of dental plate; *e* and *f*, the skin-grafted cavity and the built-out plate which occupies it. *g* and *h*, x-ray of bone-grafted jaw showing splint for inlay graft cemented to teeth.

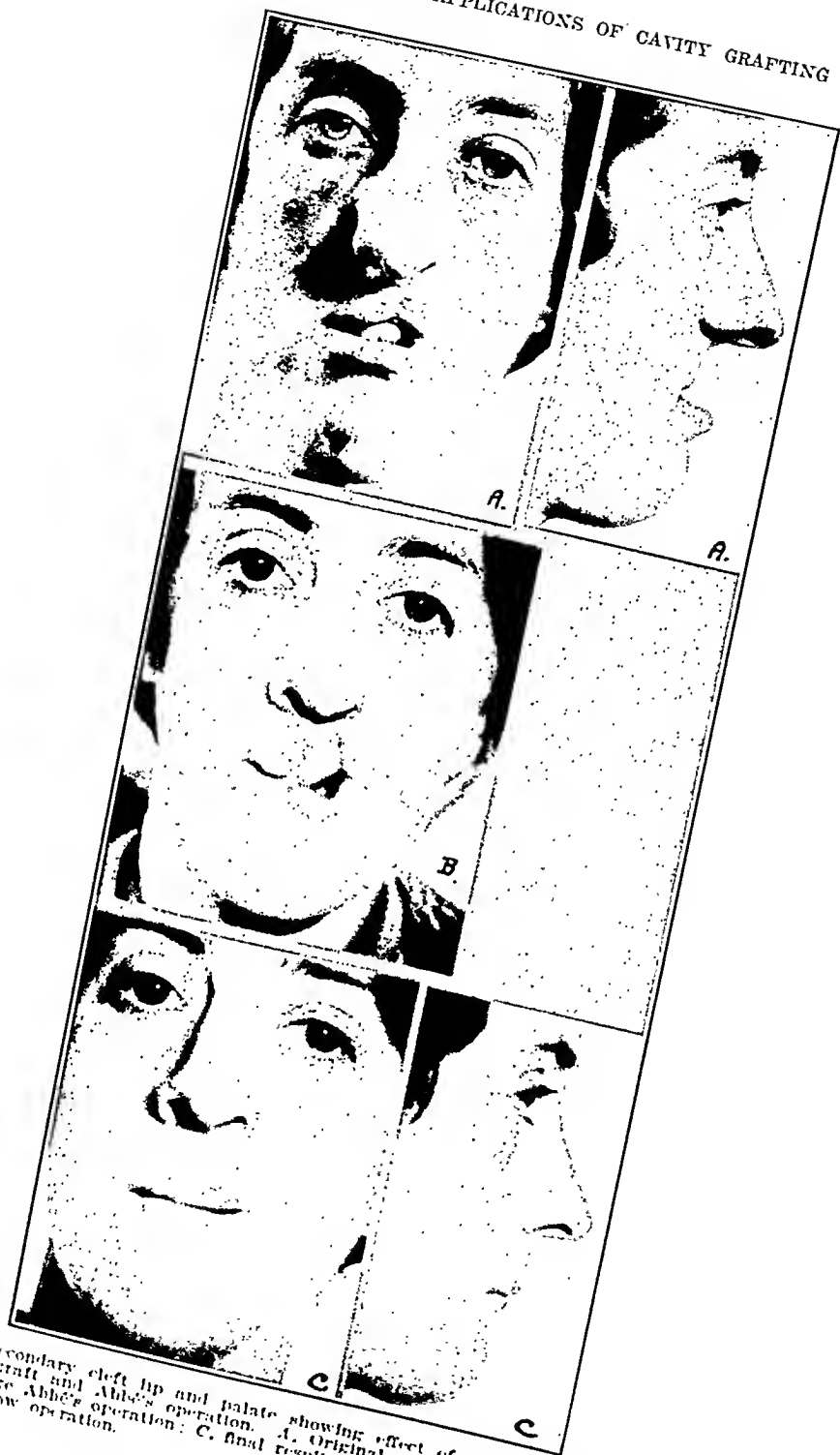


FIG. 4.—Secondary cleft lip and palate showing effect of repair of lip by postlabial inlay graft and Abbé's operation. A. Original condition. B. postlabial inlay with first stage Abbé's operation. C. final result after second stage Abbé's operation and cupid's bow operation.



Fig. 3.—Secondary cleft lip and palate, showing effect of repair of lip and post-labial inlay graft and Abbé's operation. A, Original condition. B, post-labial inlay. C, final result after repair of lip and straightening of nose.

5. In retrognathism a most satisfactory compromise can be effected simply by means of a large buccal inlay, the soft tissue of the chin being brought forward into excellent position and maintained there by a vulcanite extension of the lower denture. The complicated and none-too-satisfactory operation of bilateral bone grafting is thereby avoided (Fig. 5).

TECHNIC

As a preliminary to cavity grafting in the mouth and nose, it is necessary to work in close cooperation with a dentist skilled in the making of splints and prosthetic appliances, and in this I have fortunately had the help of Mr. E. A. Hardy, to whose ingenuity and patience I am deeply indebted. Where the lower buccal sulcus has been lost and the patient has standing teeth, a splint of the metal cap type, together with a "snap-on" removable tray, is constructed and cemented into place. In the case of edentulous patients, a combined upper and lower spring retention apparatus of the type illustrated is satisfactory (Fig. 6). When the preliminary dental work is completed, the lip is separated from the anterior surface of the maxilla or mandible as extensively as is required, care being taken to overdo the separation and to create a larger cavity than will ultimately be required.

An accurate and easily removable mold of Stent's dental compound is then made of the cavity in such a way that the retaining tray attached to the splint presses it firmly into place and overdistsends the cavity. When this is complete a one-piece Thiersch graft is cut as thinly as possible from the inner aspect of the arm and applied raw surface outward to the mold. The mold and its surrounding graft are then quickly placed in position in the cavity, and the tray fixed on. An elastoplast fixation externally helps to keep the whole firm. The immediate after-care is simple and is merely directed toward keeping the mouth clean with mouth washes, gargles, and sprays. Ordinary diet is encouraged, and the patient should have little distress after the first twenty-four hours. At the end of seven days, the tray and the mold are removed. The cavity is examined and, as a rule, will be found well grafted with possibly one or two tiny spots unhealed. These should be touched with trichloroacetic acid fused on a platinum loop. This is done as quickly as possible and the mold replaced. For the next three or four weeks, the cavity is carefully cleaned, first by the dental surgeon and ultimately by the patient, and if necessary the mold renewed—preferably with one made of gutta percha. When the graft is entirely sound, the dental surgeon can fit the permanent denture with an extension on the vulcanite plate to occupy the buccal sulcus to its full depth.

maxillary deformity which follows many of the older palate operations. The effect upon the external contour is often dramatic, and there is no question that this operation must frequently serve as the essential basis for any successful repair (Figs. 3 and 4).

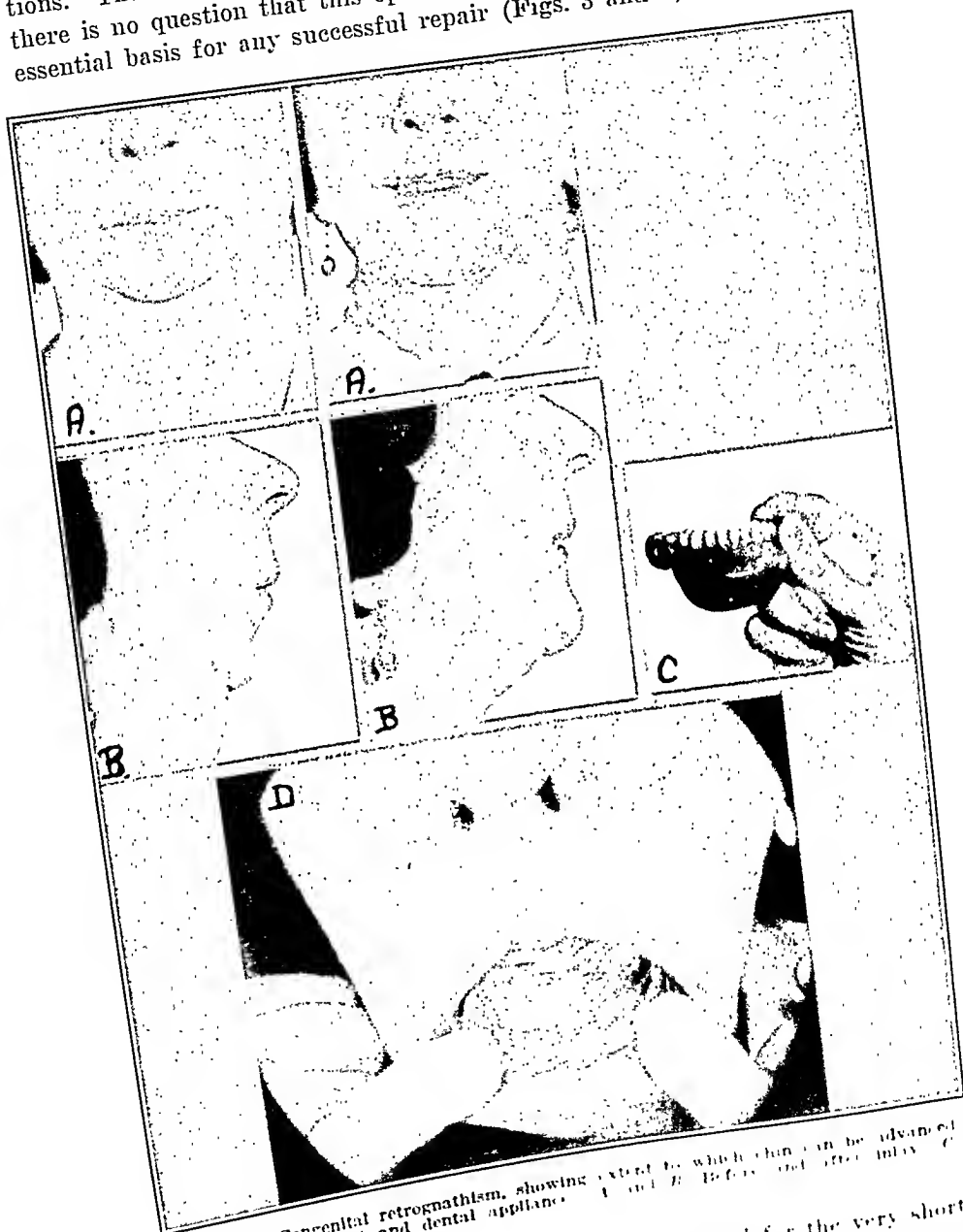


Fig. 5.—Congenital retrognathism, showing extent to which chin can be advanced by large inlay graft and dental appliance. A and B, Before and after inlay. C, denture; D, epithelial pocket.

As is well known, the Gillies operation, designed for the very short palate, requires the introduction of a skin graft into the raw area created by the separation of the soft from the hard palate.

in the case of many secondary cleft lips and palates, it is necessary to carry the incision in the upper sulcus through the nasal floor, along the membranous septum to the tip of the nose in order to obtain elevation of this part as well as of the lip. With standing teeth, the metal cap splint with a removable tray is advisable (Fig. 8).

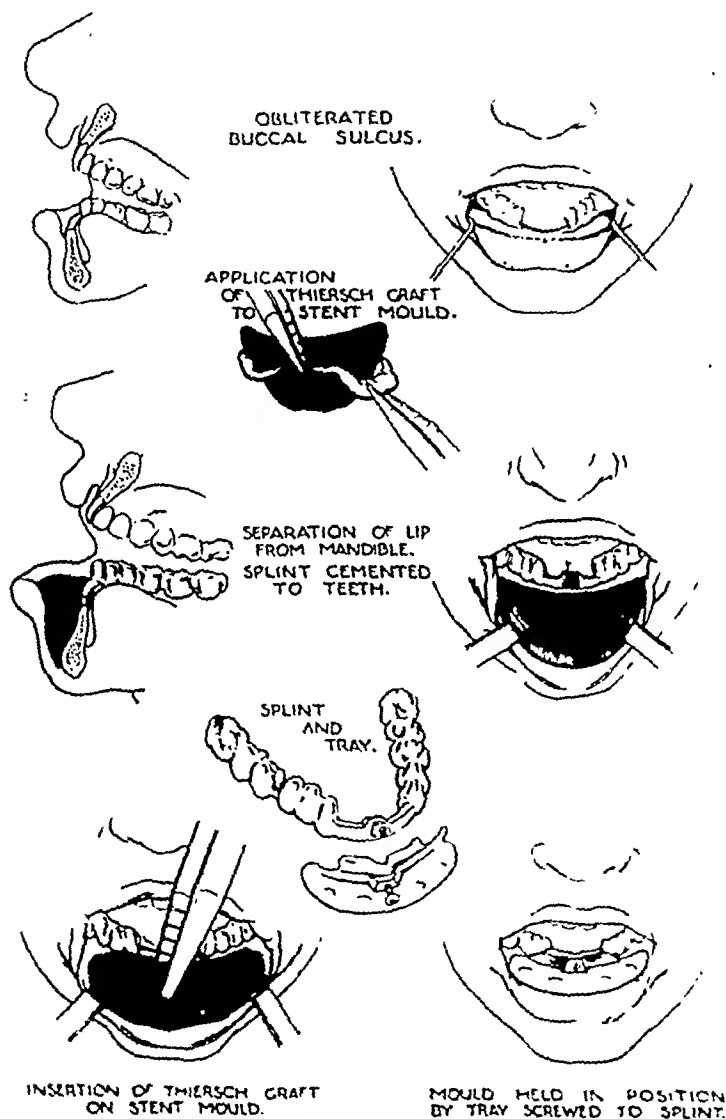


FIG. 7.—Diagram—obliterated buccal sulcus.

THE NOSE

A condition extremely difficult to treat by any other method is stenosis of one or both nares. Here an inlay on a stent mold containing a central hole through which the patient may breathe produces excellent

In the case of buccal sulci made after bone grafted fractures of the lower jaw, the deepening may be to a moderate extent and is usually on one or other side of the jaw, as the case demands. The same is true of the elderly edentulous patient with an insufficiently deep buccal

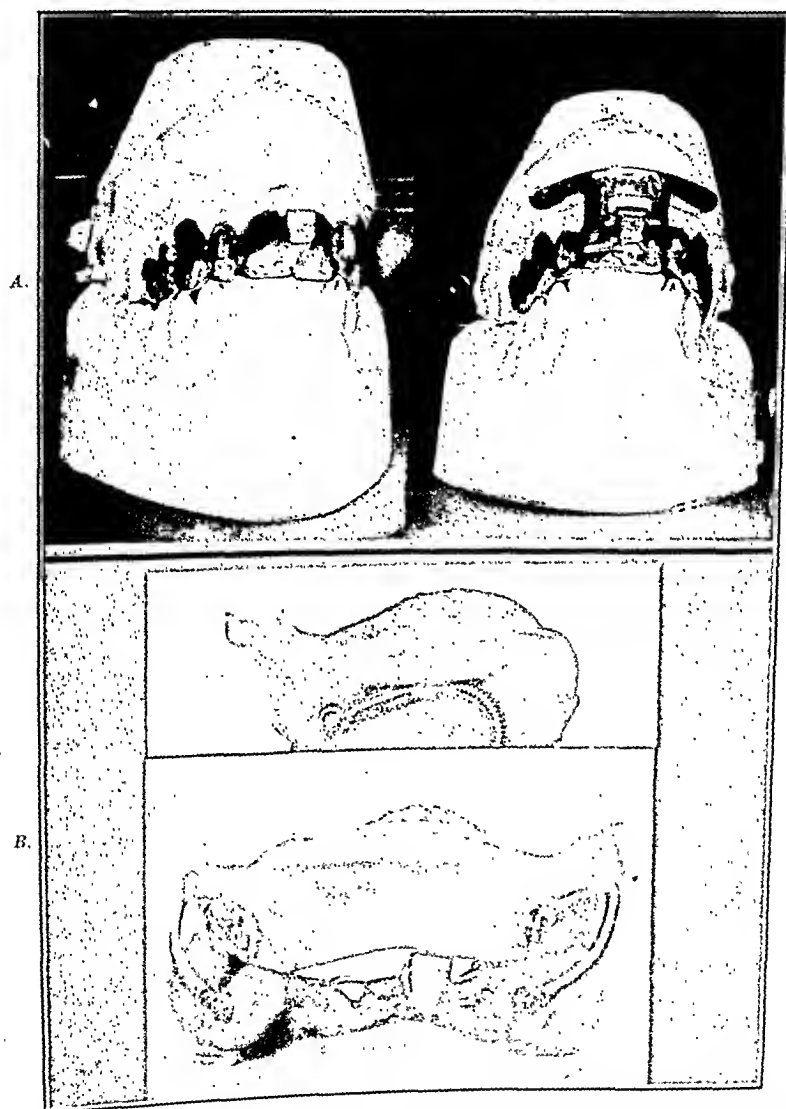


FIG. 6.—A, Splint with standing teeth. Dental model showing use of metal cap splint with "snap-on" removable tray where standing teeth exist. B, splint without standing teeth. Type of spring retention apparatus used in edentulous patients. (Hardy.)

suleus for the fitting of a stable plate. In retrognathism, the cavity lies in front of the symphysis and is usually of very large extent (Fig. 7). In the upper lip exactly the same technic is followed, except that

sues of the nose are mobilized extensively upward as far as the glabella and laterally until the nose can be brought forward well beyond its normal position. Particular attention must be paid to freeing the deep attachments of the alae nasi. I have found that in making the mold for this rather big cavity, it is more convenient to make it in two pieces, one for the nasal cavity proper, extending up over the remains of the nasal bones, and a second mold lying against the first, which occupies the lower half of the cavity and the entrance from mouth to nose. The double block makes for ease of subsequent removal and

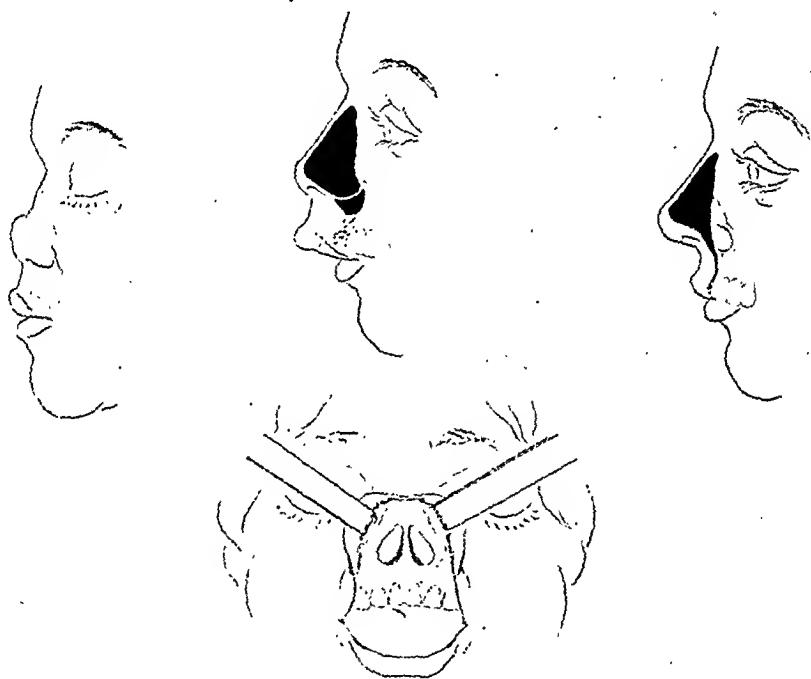


Fig. 10.—Technic of postnasal inlay, showing separation of soft tissues from underlying bones. Overdistention with retention mold and skin graft, and final result.

reintroduction. A large Thiersch graft is, as a rule, required for this type of graft, and again it is obtained from the inner side of the arm, and made as thin as possible in order not to include any epithelial appendages. It is advisable not to distend the skin over the bridge of the nose too much as an extensive inflammatory reaction may be provoked, which will prove troublesome during the postoperative course. (Figs. 11, 12, and 13.)

Postoperative treatment is identical with that of the buccal inlay, and the cooperation of the dental surgeon sought in the after-care of the grafted cavity. Occasionally some amount of suppuration occurs

results, but again it is necessary to persist with constant dilatation throughout the period of the contractile phase of the graft (Fig. 9). The most important field, however, for the use of cavity grafting of the nose is unquestionably in specific disease or congenital absence of the septum and supporting structures, and in that deformity called "dish face" which follows severe telescoping fractures of the nasal ethmoid maxillary compound. The uselessness of attempting to restore nasal or facial contour in these conditions by introducing a cartilage graft under the bridge is obvious to anyone who has ever tried

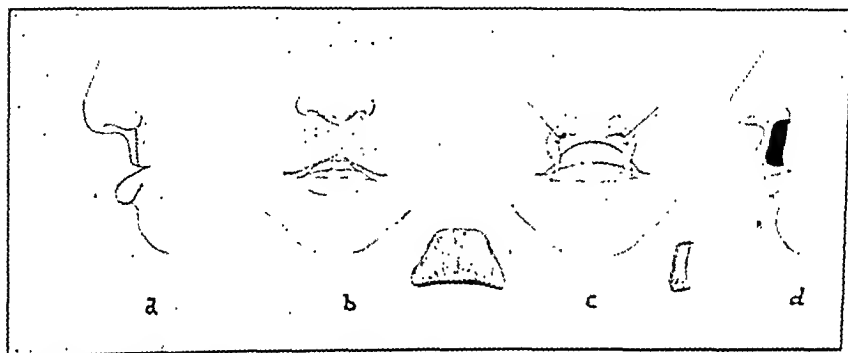


Fig. 8 (a-d).—Retroposed upper lip showing extent of mobilization and the type of mold used to bring it forward.

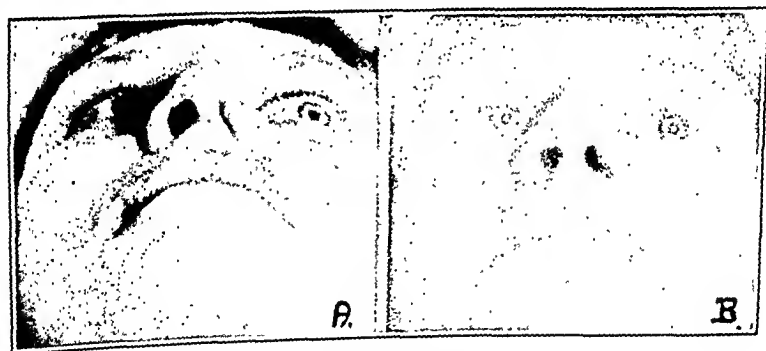


Fig. 9.—A, Stenosis of left nostril; B, result of treatment by inlay graft on gutter-percha mold.

it. In the specific nose, the essential lesion is loss of nasal mucous membrane, although other structures may be destroyed in addition, and satisfactory reposition cannot be effected unless a new postnasal lining is supplied. The method is practically the same as for the upper buccal inlay, but in this case separation is carried back ruthlessly into the nose (Fig. 10). As a rule the septum has been almost completely destroyed, and the incision in the upper buccal sulcus from canine to canine is deepened upward, leading directly into the nasal cavity formerly occupied by the septum and turbinates. The soft tis-

just above the inner canthus of both eyes. This is due either to the mold being too tight or to inadequate drainage at this point. In some cases I have removed the mold and made it smaller, and at the same



FIG. 12.—A, Congenital specific destruction of nose. B, result after postnasal inlay. C, retention apparatus in situ. D, inlay showing communication between nose and mouth.

time punctured the abscess on each side internally; in others I have held on and even allowed an abscess to be opened on the side of the nose. Certainly the worst thing is to remove the stent entirely and

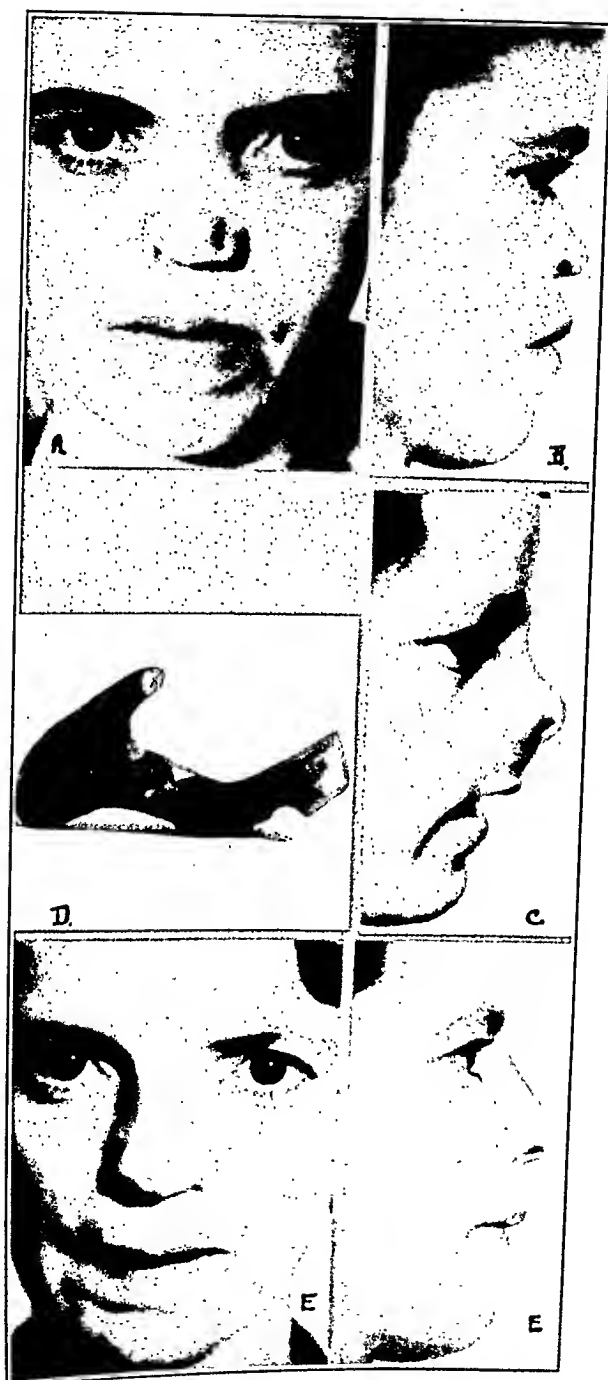


Fig. 11.—A and B, Congenital specific destruction of nose; C and D, postnasal incision and retention apparatus; E, final result.

The toilet of the new eye socket is rather important, inasmuch as if neglected, the skin may tend to desquamate and smell rather badly. It should be carefully cleansed twice a day after removal of the shell, wiped out with a little spirit, and lubricated with paraffin and rose water.

THE EAR

Traumatic stenosis of the external auditory meatus can be easily dealt with by this means. The following case illustrates the method adopted.



Fig. 14.—A, Contracted socket; B, result of treatment by razor graft; C, result of fitting of artificial eye.



Fig. 15.—A, Contracted socket; B, mold covered with thin razor graft has been in position for two months; lids sewn together; C, eye socket after removal of mold; D, artificial eye fitted.

The patient had been thrown from a motorcar onto the road, and his left ear torn from his head and left attached to a flap of skin on his cheek. It was hastily replaced as a roadside emergency and when healed it was discovered that the external auditory meatus was completely stenosed and the ear half an inch lower on the left side than on the right. The patient was, of course, completely deaf on that side. End-to-end anastomosis of the severed meatus was out of the question, because it had been torn off flush with the bone (Fig. 16). In this instance I turned back a flap, exposed the bony meatus, and after careful dissection discovered the inner end of the meatus about a quarter of an inch from the tympanic membrane.

allow the inflammation to subside. Removal of the stent in the early stages for more than a few hours means, of course, the complete contraction of the cavity. When the contractile phase is over, the dental surgeon can then fit a vulcanite retention apparatus which supports the nose permanently. In certain cases, this retention apparatus can be dispensed with and a cartilage graft substituted, while the communication between the nose and the mouth is closed.

THE EYE SOCKET

A common condition after extirpation of the orbit is contraction of the socket to the extent where an artificial shell cannot be fitted or

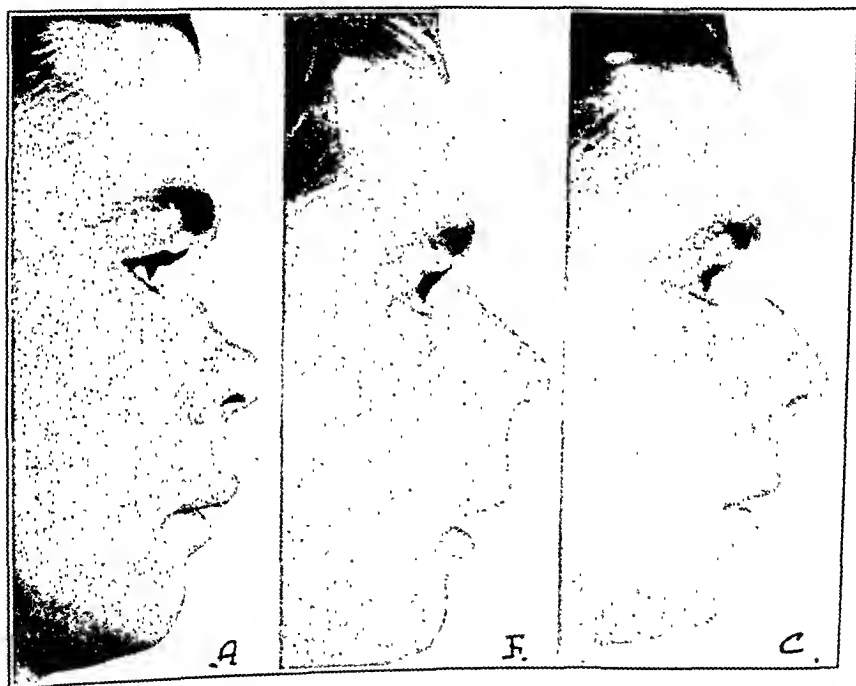


FIG. 13.—*A*, Dish-face deformity; *B*, preliminary overdistention; *C*, final result with dental prosthesis.

retained. Mucous membrane grafts for this condition are, as a rule, totally inadequate and difficult to apply. A simple and very satisfactory application of the epithelial inlay will solve the problem. The mucous membrane of the contracted socket, together with all the scar tissue of the orbit, is dissected out. This includes what little mucous membrane remains on the posterior surface of the lids. A gutta serena mold covered with hairless Thiersch graft is inserted into the cavity and the eyelids carefully sutured together over it. The mold is left in place for a period of four to six weeks, and if possible longer. At the end of this time the lids are separated, the mold removed, and an artificial shell fitted. (Figs. 14 and 15.)

ear, ossicles, and cochlea remain. In several instances of this condition, I have opened the mastoid, determined the presence of ossicles, and skin grafted the bony canal leading to the middle ear (Fig. 17). Otoplasty can then be performed round the meatus so formed. Although the number of cases in which hearing is improved is very small, I believe the attempt is justifiable.

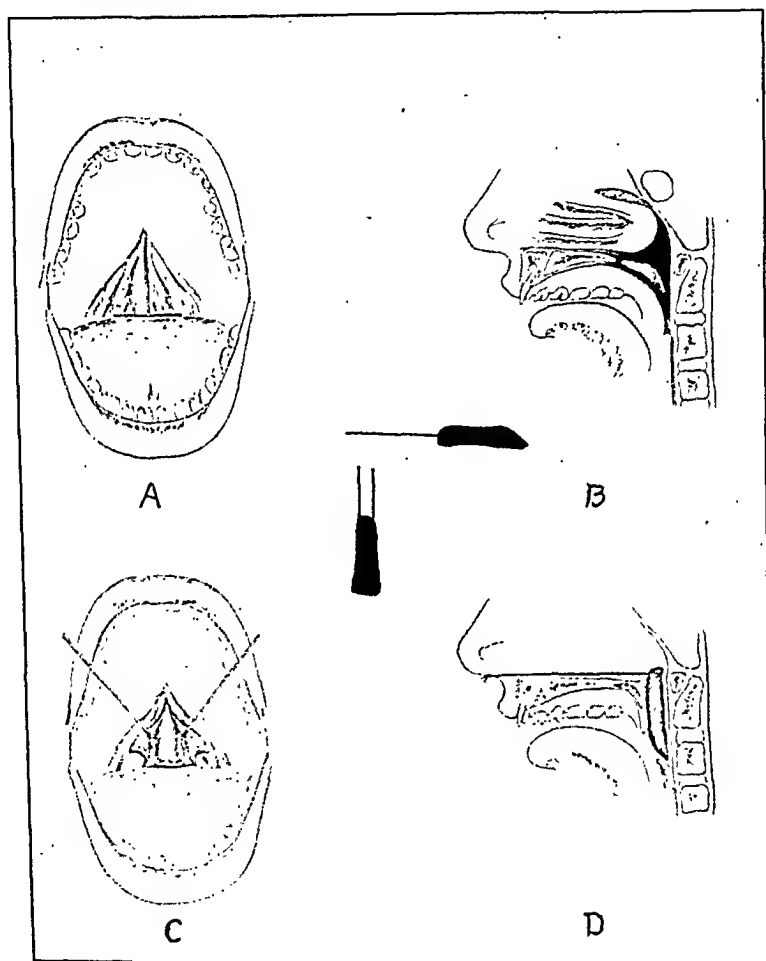


FIG. 18.—A and B, Syphilitic stenosis of palate, showing complete and extensive attachment of soft palate to posterior pharyngeal wall. C and D, after separation of the palate, a stent mold is introduced, covered with thin razor graft, and maintained in place for two months by a silk thread.

THE POSTERIOR PHARYNGEAL SPACE

One of the most difficult conditions which one can be called upon to treat is complete obliteration of the oronasal space due to specific disease, or to a disastrous tonsillectomy. The extent of the stenosis is usually so widespread that manipulation of flaps fails to create a passage from the pharynx to the nose. The complete absence of nasal

A large cavity was made communicating with the central remains of the meatus and this filled with a block of gutta percha covered with thin skin. The skin graft was practically in contact with the tympanic membrane. The whole ear was sutured back over the mold, and a small drain left in a dependent position. The mold remained in situ for three months, during which time there was a considerable amount of discharge from the drain hole, but nothing else to indicate any serious inflammatory reaction. At the end of three months, I again turned the ear forward and found a perfectly soft, completely skin-lined cavity on the inner side of which was

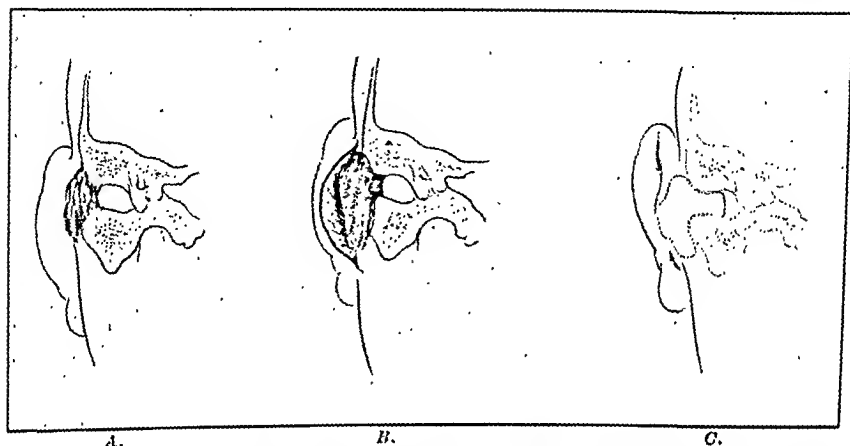


Fig. 16.—*A*, Traumatic stenosis of external auditory meatus; *B*, separation of ear posteriorly, removal of fibrous tissue mass, isolation of inner end of incus, and insertion of skin-covered mold into cavity; *C*, skin-lined cavity connected to external ear three months later after removal of mold.

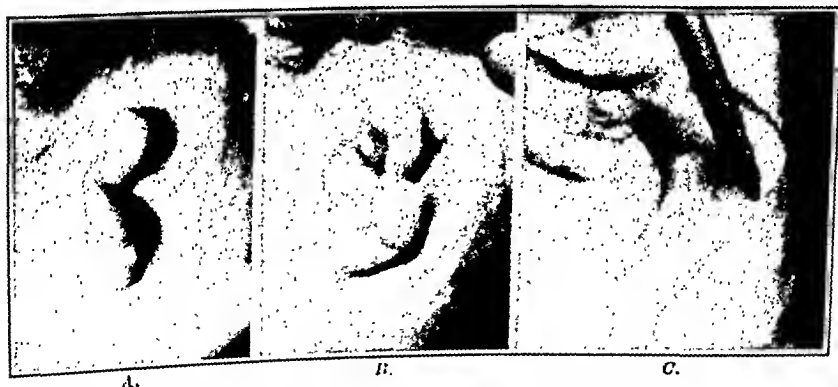


Fig. 17.—*A*, Congenital absence of external auditory meatus; *B* and *C*, middle ear has been opened through mastoid and skin grafted, patent meatus shown.

the patent bony meatus and the tympanic membrane. It was then a comparatively simple matter to anastomose the outer side of the cavity to the outer end of the meatus, and to replace the ear in its normal position. The result has been completely satisfactory, and the hearing is now restored.

An occasional use for cavity grafting in the ear is in the condition of congenital absence of the external ear and external auditory meatus, where there is strong evidence, x-ray and otherwise, that the middle

I believe, more encouraging results. In the past, attempts have undoubtedly been made to reconstruct a urethra by means of Thiersch grafting, but a close examination of the reported cases convinces me that those who attempted this method were wrong in principle, in that intermittent dilatation was considered sufficient to maintain the patency of the skin-lined tube, whereas, as in every other type of epithelial

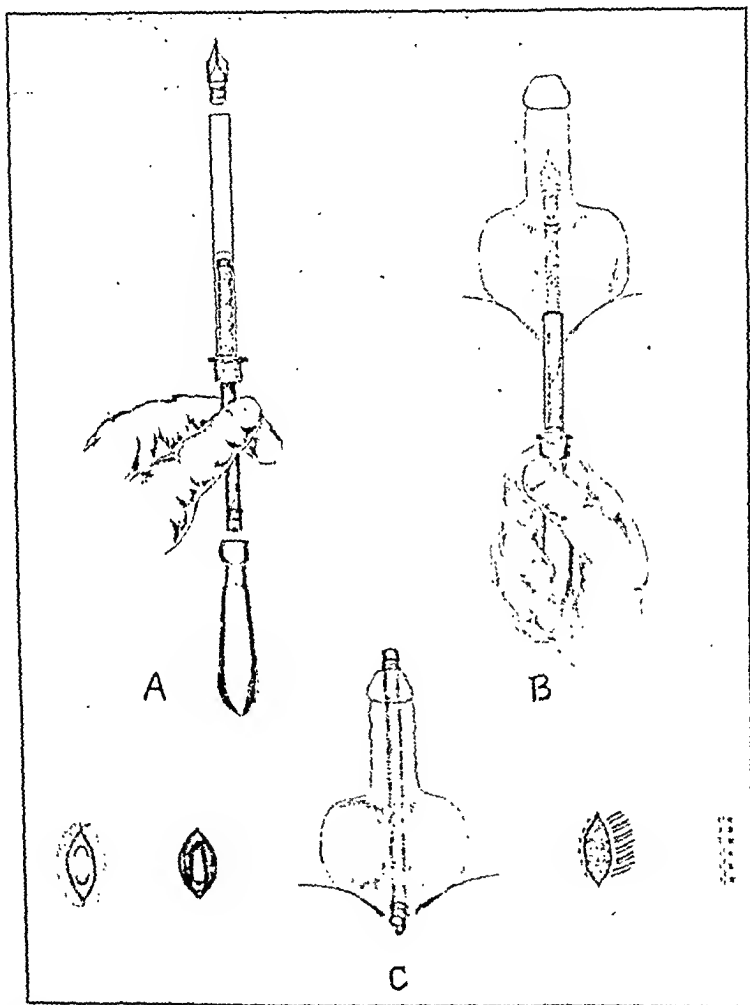


Fig. 26.—A, Author's skin graft introducer for hypospadias; B, method of insertion; C, inlay graft in position. Insert shows method of anastomosis of new urethra to hypospadiac meatus.

inlay, continuous and prolonged dilatation is necessary from the first until the contractile phase common to all free skin grafts is over.

Utilizing the inlay principle, two methods are available: (a) The open method by which at one operation the penis is split ventrally, the remains of the corpus spongiosum removed, and an inlay graft

drainage produces an indescribably septic condition of all the accessory sinuses and makes the condition of these patients miserable in the extreme.

I have found that after boring a hole between the adherent palate and the posterior pharyngeal wall from the pharynx into the nasal cavity, and inlaying skin on a mold retained by double silk threads tied round the columella and retained in place for at least two or three months, an excellent passage can be made (Figs. 18 and 19). Drainage of the nasal cavity and sinuses is effected with remarkable improvement in the general health of the patient.

THE URETHRA

Those who undertake the responsibility for the radical cure of hypospadias know that the condition is one of the most difficult of all surgical operations to bring to a successful conclusion. The difficulty



Fig. 19.—Complete specific stenosis of posterior pharyngeal space cured by an inlay graft.

lies not so much in technical performance as in obtaining healing *per primam intentionem* by methods which necessarily violate all the principles of plastic repair. Most operations attempt to reconstruct an epithelial lined urethra at the expense of the skin of an already attenuated organ which is little able to afford such a loss. The result is only too frequently undesirable tension of flaps, superimposed suture lines, indifferent blood supply to skin edges, and consequent breaking down of the new urethra in part if not completely. My own experience in the primary repair of hypospadias is not unique in that I have been exceedingly dissatisfied with my results and with the methods employed to gain them. Particularly is this so in adult males with hypospadias in whom so many unsuccessful operations in infancy have been performed that failure with any form of flap operation is a foregone conclusion. Consideration of this particular type of adult patient has led me to experiment with the principle of the epithelial inlay with,

skin-covered catheter along a tunnel two or three inches in length, without rucking the skin off the catheter and so leaving raw areas ungrafted. I, therefore, constructed an introducer which obviates this difficulty very simply. The instrument resembles a suprapubic trocar except that the handle and the cutting point can be unscrewed, leaving a smooth barrel five inches long, open at both ends, which will just admit a piece of No. 11 gum elastic (Fig. 20). The method is as follows:

A thin Thiersch graft is cut from the inner side of the arm and carefully applied raw surface outward, like a piece of cigarette paper, to the section of catheter, which is then carefully placed in the barrel of the instrument, and the cutting point and handle screwed on. A small stab incision is made just distal to the orifice of the perineal or penile meatus, and another at the dimple usually present at the tip of the glans. With the patient in the lithotomy position, the trocar introducer is then thrust along the penis subcutaneously from the posterior stab incision until the point emerges at the tip of the penis. It passes between the ventral penile skin and the corpora cavernosa. This maneuver, while not easy, can be facilitated by the introduction of a long pair of slender scissors with Mayo points, in order to divide any fibrous bands which obstruct the passage of the instrument. The cutting point of the introducer is then unscrewed and the end of the skin-covered catheter gripped firmly with a pair of forceps. The barrel of the instrument is then carefully withdrawn and the skin-lined urethra rinsed through with saline or half-strength Eusol. A fresh piece of catheter is immediately placed in the urethra. Sitz baths and syringing should be persevered with daily at the same time until healing is complete. At no time during the next three to four months should the new urethra be left without its catheter in place, and the patient himself must be warned against this. At the end of that time, the contractile phase is over, and the catheter may be safely left out. In six months, end-to-end anastomosis of the posterior end of the new urethra and the perineal fistula is performed over a short piece of catheter (Fig. 21).

The result of this operation is the most normal looking urethra which can be obtained by any method yet described. This is particularly true of the meatus, which can thus be made to appear at its usual position in the glans, something which no flap operation can accomplish.

spread on a catheter of a large size placed in a groove along the whole length of the lengthened penis, being brought out at the glans anteriorly and at the perineum posteriorly. The graft is well oversewn, and the entire organ bandaged in a mastisol case to obtain the neces-

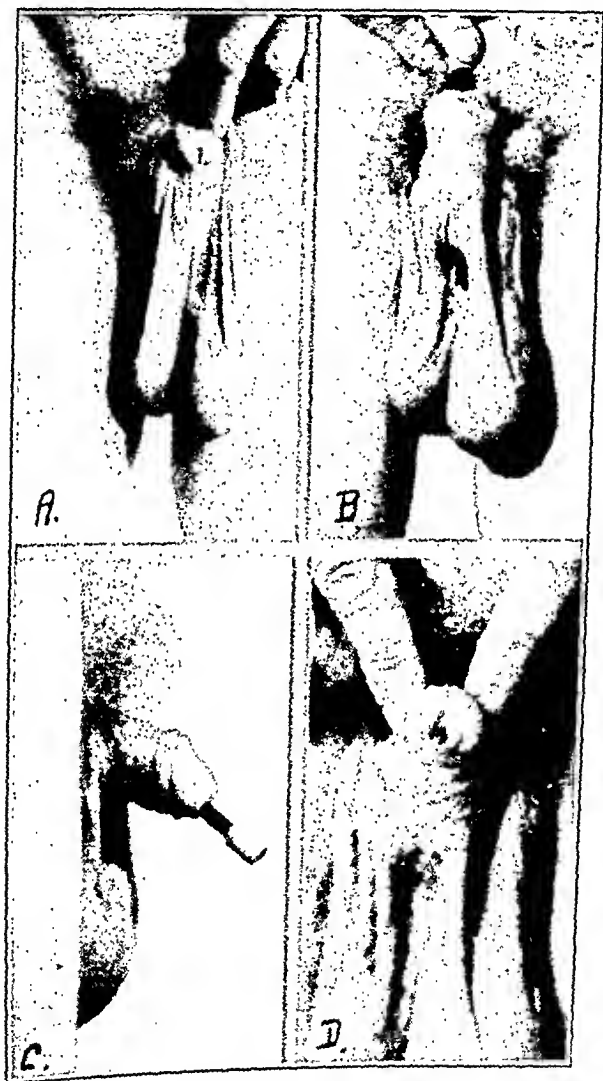


Fig. 21.—A, Primary adult scrotal hypospadias; B, epithelial inlay after Edmunds' straightening operation; catheter No. 11 in place for five months; C, showing correction of ventral curve; D, final result after end-to-end anastomosis, note normal appearance of meatus.

sary pressure. This method is being developed by Sir Harold Gillies.
 (b) The closed method, which is used after straightening has been accomplished at a preliminary operation by Edmunds' method. The difficulty of applying this method is the mechanical one of passing a

skin-covered catheter along a tunnel two or three inches in length, without rucking the skin off the catheter and so leaving raw areas ungrafted. I, therefore, constructed an introducer which obviates this difficulty very simply. The instrument resembles a suprapubic trocar except that the handle and the cutting point can be unscrewed, leaving a smooth barrel five inches long, open at both ends, which will just admit a piece of No. 11 gum elastic (Fig. 20). The method is as follows:

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HOMOGRAFTING OF SKIN: WITH REPORT OF SUCCESS IN IDENTICAL TWINS

JAMES BARRETT BROWN, M.D., F.A.C.S.
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(From the Department of Surgery, Washington University School of Medicine)

IT HAS been generally found that skin transplanted from one individual to another does not survive permanently. Many reports of success originate from occasional observers but, when the patients are examined, one cannot be sure that any graft is present. The usual course in these patients is that, following a possible "take" of the graft, there has been survival for two weeks, but total absorption of the graft by the end of the third week. This has been followed by a period of granulation, and then spontaneous epithelization has occurred, perhaps somewhat rapidly—and in some instances it has apparently been mistaken for transplanted skin. A very occasional homograft might survive, but the chance is so remote that, on an active surgical service where many skin grafts are done, the method could not in any manner be relied upon.

Suggestions have been made to try to insure permanency of these grafts, the best known of which is that the donor and recipient should be of the same blood group, but there is no measurable value of this selection of donor skin either in the "take" of the graft or its survival. Other methods have been something like desensitizations—injection of the recipient's blood around the graft site on the donor, delaying the graft and exposing it to the recipient's serum, and doing preliminary transplants to try to accustom the donor to the presence of foreign skin. The method of Stone in the culture of donor parathyroids in the recipient's serum has so far not been reported successful in working with skin, but may prove to be possible, at least, for the single element of epithelial cells. The successful solution of this problem would be one of the major advances in reconstructive surgery, but for the present, the patient's own available skin must be depended upon. By using thick split skin grafts (thick Ollier-Thiersch grafts) in all possible repairs, one can usually find sufficient quantity of donor skin and by careful removal of the grafts, the same donor site may be used as many as three to four times.

In two instances, I have used homografts from the mother to tide over very serious periods in the care of patients whose conditions might otherwise have proved fatal, and, in both instances, it was thought that the

two weeks' respite that was afforded the patients from the open wound was the turning point in their outcome.

The boy shown in Fig. 1 had a deep burn which extended very close to the peritoneum. His reaction to any type of treatment was extremely bad, and from the irritation and itching around the wound, he

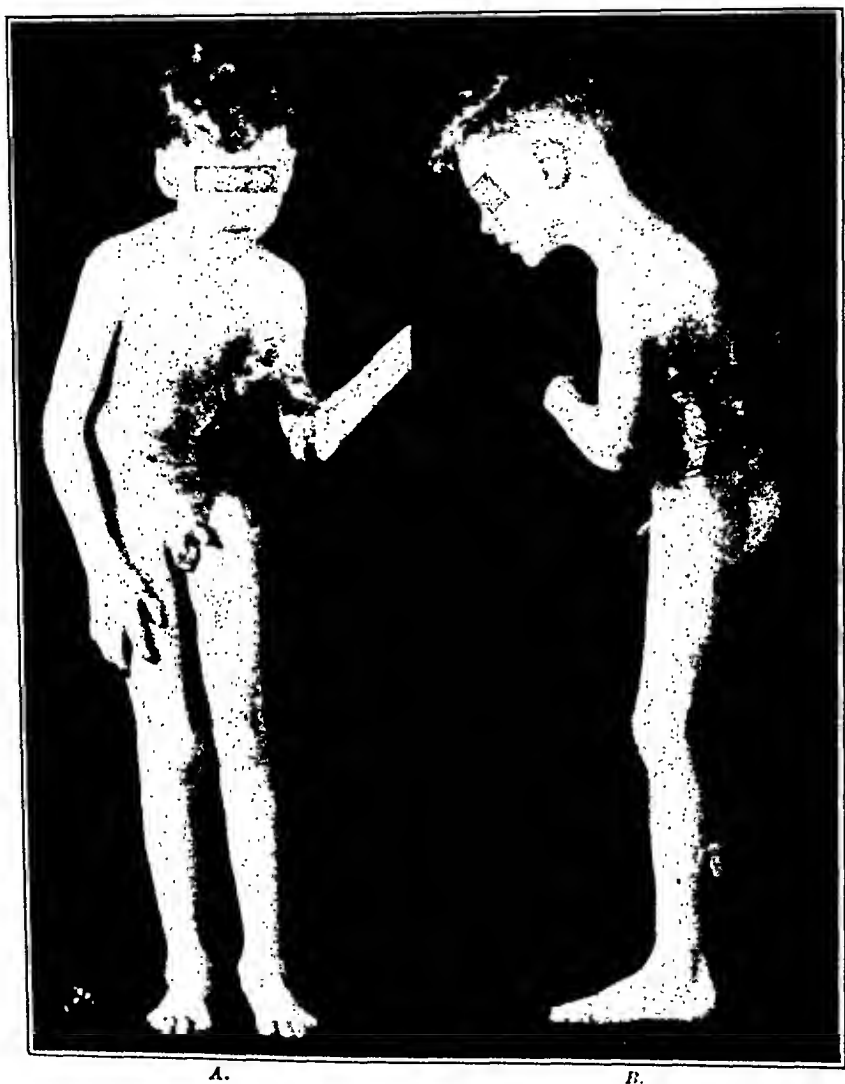


FIG. 1. A and B.—Condition of patient at time homografts from mother were applied.

developed an abnormal desire to rub and scratch the area. His general health went down so badly that it was feared he would not survive. Then, as a last resort, to provide a covering for the wound, thick split homografts from the mother were applied to the entire area to remain in place for as long as they might last. There was immediate local and

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A second patient, who had even a more refractory course and worse reaction to pain, was treated in the same manner except that only one-third of her wound was covered, because it was a complete circular loss on the thigh, and it was not thought best to sacrifice this much donor skin (Fig. 4). Fig. 5 shows a complete "take" of thick split grafts



Fig. 4.—Shows very dirty wound from complete, circular full thickness loss of skin. Patient, on one occasion, had been taken from hospital by parents because of extremely bad reaction to treatment.

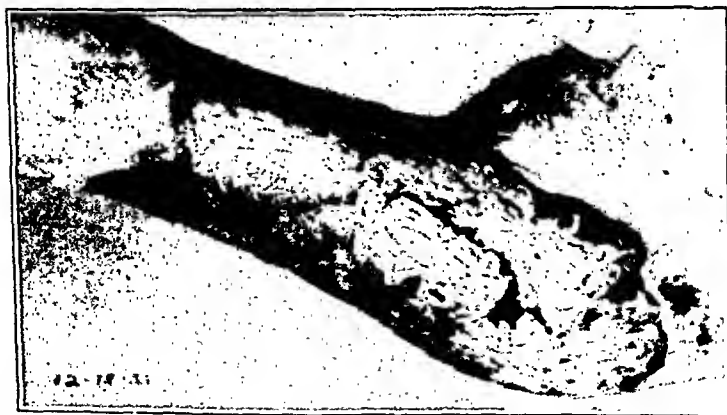


Fig. 5.—Photograph made at time of first dressing, four days after operation, showing complete "take" of thick split grafts which had been taken from patient's mother at time of operation. These grafts persisted about two weeks.

from the mother after four days; following this, there was marked alleviation of the patient's pain reaction, and the wound and general condition steadily improved. These grafts were entirely gone in two and one-half weeks, but the greatly improved appearance of the wound after

general improvement, the grafts took almost perfectly, and for two weeks, while the grafts survived, the child was comfortable. By the end of the third week, the grafts were completely absorbed, but the wound was much improved, and the patient was comfortable. There was then apparently a real stimulus to his own spontaneous epithelization, and

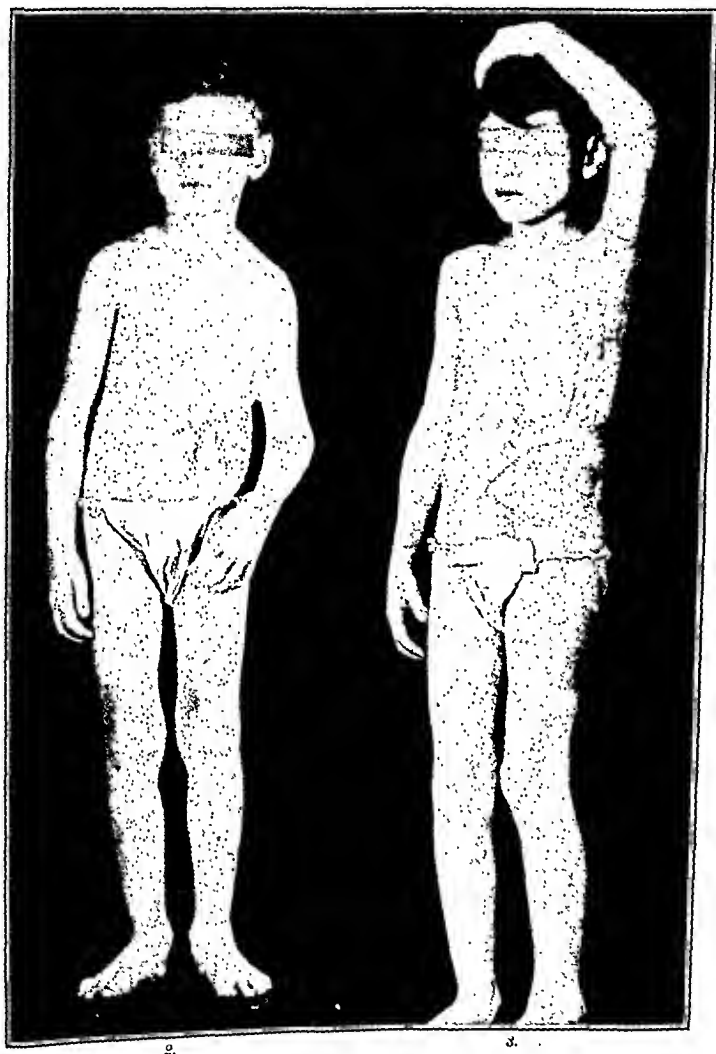


Fig. 2.—After homografts had been in place two weeks and then had been completely absorbed, there was fairly rapid spontaneous healing with the deformity shown here.

Fig. 3.—Result after release of deformity and removal of scar, and application of thick split grafts from the thigh to the axilla, arm, chest, and abdomen.

the area rapidly covered over, as shown in Fig. 2. Release of scar tissue and resurfacing with thick split grafts could then be done, so that the final result, as shown in Fig. 3, was obtained.

three weeks is shown in Fig. 6; the granulations are firm, and the epithelial edge is spreading. The islands of epithelium are from implantation grafts that had been put in before the homografts were applied, but which had not given evidence of enlarging. The final result, as shown in Fig. 7, was obtained in two operations with thick split grafts from the opposite thigh.

For several years I hoped to have the opportunity of using homografts from an identical twin, but never encountered a burned patient with a twin, and then, through the courtesy of Dr. O. J. Wilhelmi, I contacted

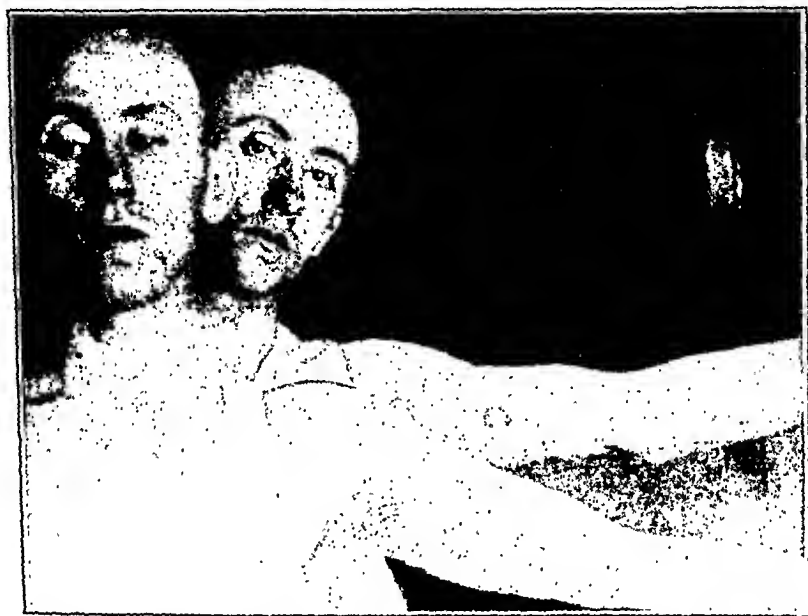


Fig. 8.—Complete and permanent survival of full thickness grafts transferred from the arm of one identical twin to that of the other. The darkened edge is a moderate keloid formation.

identical twins who kindly donated their time and small areas of their skin for cross transplantation. Accordingly, I transferred full thickness skin grafts from the arm of one twin to that of the other and obtained primary healing in both with complete and permanent survival of both grafts. Fig. 8 shows the grafts after five months; they have now been in place three years. Padgett also has noted the survival of homografts in identical twins.

REFERENCE

Padgett, E. C.: Is Iso-Skin Grafting Practicable? *South. M. J.* 25: 895, 1932.



Fig. 6.—Shows same leg twenty-two days later with complete solution of the homo-grafts, but much improvement in appearance, with beginning healing.

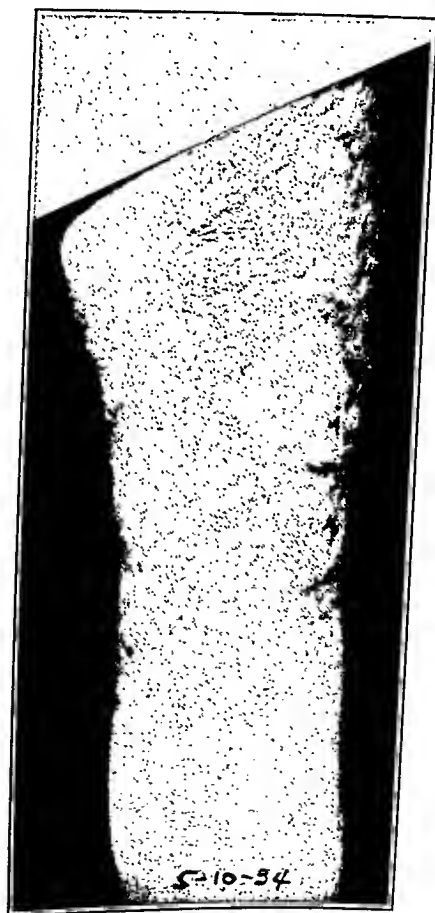


Fig. 7.—Final restoration with thick split grafts from the opposite thigh.

tively its effect on the circulatory system was indistinguishable from that of epinephrine; however, it is less potent in its action, being a twelfth as active as levorotatory epinephrine. They attributed the activity of the substance, when given by mouth, to the shifting of the methyl group from the nitrogen atom to extend the side chain by two or three carbon atoms. The levorotatory form is two or three times more active than the dextrorotatory form, and it is 60 to 65 per cent as active as levorotatory epinephrine. The oral activity of ephedrine, likewise, has been shown to be the result of the presence of a third carbon atom in the aliphatic side chain. Barger and Dale showed that the introduction of two hydroxyl groups into the aromatic nucleus, one in para and the other in meta position, resulted in maximal pressor activity.

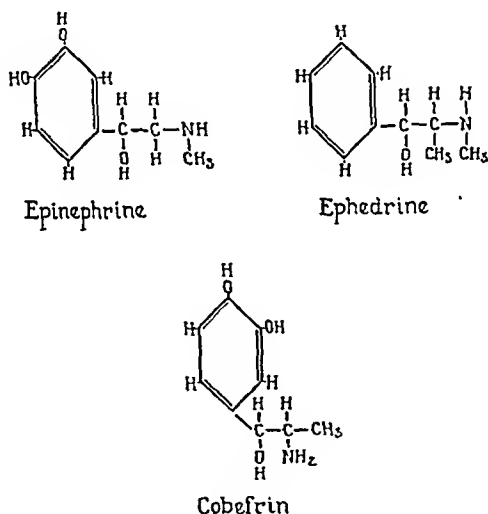


Fig. 1.—Chemical structures of epinephrine, ephedrine, and cobefrin.

Cobefrin has been used clinically in combination with a solution of procaine to produce local anesthesia, by several German workers. Hirsch has employed this combination for tonsillectomy and various other operative procedures on the eyes, ears, nose, and throat. He commented that the advantage in the use of cobefrin is that it does not cause a sudden fall in blood pressure through a vagal reflex. This, he asserted, is responsible for the lack of untoward subjective symptoms such as tremor, dizziness, palpitation, and minor syncopal reactions. Furthermore, he said that cobefrin may be given to individuals who have an idiosyncrasy to epinephrine, without fear of any untoward symptoms or reaction. Hermann and Ruthsatz confirmed the observations of Hirsch and also made similar recommendations as to the usefulness of this new agent.

A COMPARATIVE STUDY OF THE PHYSIOLOGIC ACTIVITY OF COBEFRIN AND EPINEPHRINE*

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SINCE 1894, when Oliver and Schäfer found that the extract obtained from suprarenal glands produced a rise in blood pressure when injected intravenously into animals, much interest and work has been devoted to this pressor substance, as well as to other pressor compounds. Abel is said to have isolated the first hormone from these glands; however, Takamine and von Fürth have contributed much to the knowledge of this new substance which was called "epinephrine" by Abel, "adrenalin" by Takamine, and "suprarenin" by von Fürth. Shortly after the discovery of the hormones, Jowett demonstrated that its chemical identity was (3, 4-dihydroxyphenyl)-1-methylanino-2-ethanol. Barger and Dale were among the earliest investigators to study its activity when it was modified slightly by various substitutions. In 1923, Chen observed that a preparation obtained from the plant *ma huang* also had a distinct pressor activity, and he noted that its action was not unlike that of epinephrine. The well-known work of Chen and Schmidt hardly needs further comment. The pressor substance, ephedrine, which they isolated from plants of the genus *Ephedra* has one advantage over epinephrine, namely, that it is active when administered by mouth.

Hartung, in a classic review of epinephrine and allied compounds, has demonstrated that an isomer of epinephrine, which possesses the same pressor activity as epinephrine, is much less toxic than epinephrine and is active when administered orally. This substance, which has been identified for some time, was known formerly as nor-homoepinephrine, or 3, 4-dihydroxyphenylpropanolamine. It is now known as cobefrin. A comparison of the structural formulas of epinephrine, ephedrine, and cobefrin is shown in Fig. 1.

Hartung and Munch found that when 3, 4-dihydroxyphenylpropanolamine was injected intravenously into rabbits, its toxicity was less than a hundredth as great as that of epinephrine, and that qualita-

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a characteristic notch in the curve, vagal slowing, and a slight secondary fall in blood pressure. This was the first record of the blood pressure in eight experiments which in any measure simulated the classic response to the administration of epinephrine (Fig. 3). The responses obtained when commercial epinephrine was used closely resembled the effect that is produced on a vagotomized animal. It seemed plausible, in view of these findings, that there was some substance present

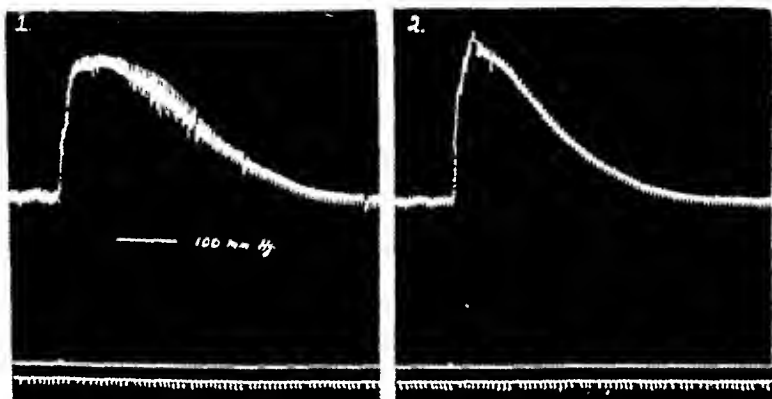


FIG. 2.—The effect on the blood pressure of an intravenous injection of (1) 0.35 mg. of cobebrin and (2) 0.07 mg. of epinephrine; weight of the dog was 7 kg.; the duration of the pressor effect of cobebrin is slightly longer than that of epinephrine.

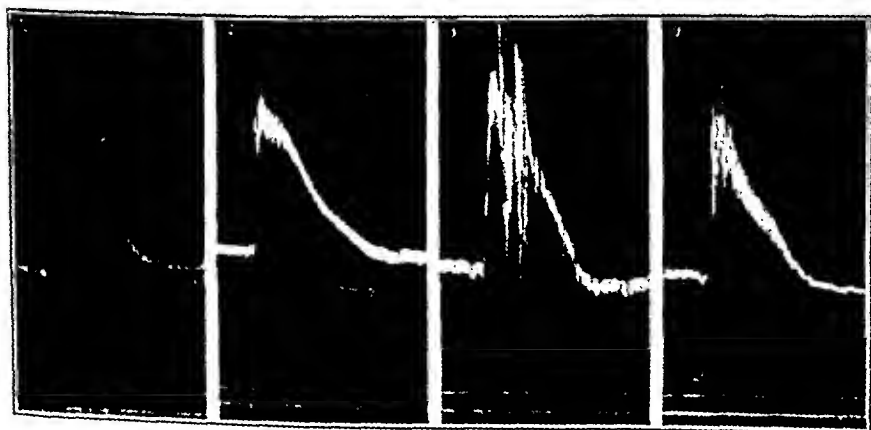


FIG. 3.—The effect on the blood pressure of an intravenous injection of (1) 0.12 mg. of highly purified epinephrine, (2) 0.12 mg. of commercial epinephrine, (3) 0.13 mg. of crude epinephrine (estimated dose), and (4) a mixture of 0.065 mg. of cobebrin and 0.065 mg. of commercial epinephrine; weight of the dog in (1) and (2) was 12 kg. and in (3) and (4), 25 kg.; one may note the vagal reflex and a decrease in the blood pressure in (3).

in the crude epinephrine which is absent in the preparation now supplied commercially. In several instances we found that even after vagotomy the heart showed evidences of vagal-like slowing when crude epinephrine was injected intravenously. This, at least, suggested the possibility of local activity on the heart and not a reflex inhibitory mechanism.

Cobefrin, as it is supplied commercially, is said to be seven and a half times less toxic than epinephrine when injected into albino rats, and its average pressor action is a fourth to a fifth that of epinephrine. Thus, a 0.5 per cent solution of cobefrin should be equal in strength to a 0.1 per cent solution of epinephrine.

Because of the assertions that have been made relative to the activity of cobefrin, studies were carried out in order to compare its activity with that of epinephrine. These studies included observations of: (1) the effect of the drugs on the blood pressure; (2) the action of the drugs on the isolated heart of the rabbit; (3) the action of the drugs on the isolated uterine of the virgin guinea pig; (4) the action of the drugs on the lungs; (5) the site of destruction of the drugs; and (6) the hyperglycogenic properties of the drugs. The effect of the drugs on the blood pressure was observed while the animals were under general anesthesia (sodium amytal or ether), and before and after the animals had been subjected to hepatectomy.

EFFECT OF COBEFRIN AND EPINEPHRINE ON BLOOD PRESSURE

While the animal was under general anesthesia.—Dogs were anesthetized with sodium amytal (sodium isoamylethylbarbiturate) or ether, and the blood pressure in the carotid or femoral arteries was recorded. A 0.1 per cent solution of epinephrine and a 0.5 per cent solution of cobefrin were used for comparison of pressor activity. A uniform dosage (0.01 c.c. for each kg. of body weight) of each substance was given intravenously.

It was found that the resulting increase in the blood pressure is maintained for a longer period of time with cobefrin than it is with epinephrine (Fig. 2). In the series of experiments with cobefrin, it was most noteworthy that the constantly occurring vagal slowing, which accompanies the vasopressor activity of crude epinephrine, was eliminated. We were not able to reproduce a typical response of the blood pressure curve to the administration of epinephrine by using the commercial preparation at hand. Similar doses of highly purified epinephrine* were injected intravenously, but the resulting increase in the blood pressure was practically identical with that which followed the administration of commercial epinephrine; no vagal inhibition was noted. Its action differed from that of cobefrin in only one respect, namely, that the duration of the pressor effect was shorter. It was suggested that crude epinephrine made from whole suprarenal glands of beavers, that is, epinephrine which was made from the cortical and medullary portions of the glands, possibly might produce a different response; therefore, epinephrine was made according to the original technic of Abel. The administration of this preparation elicited a pressor response with

*Obtained from E. C. Kendall, the Mayo Foundation, Rochester, Minn.

the two kymographic records of the blood pressures, save that the record obtained before hepatectomy shows a little more evidence of vagal inhibition with slowing of the heart rate than does the record obtained after hepatectomy. The duration of the pressor effects was practically the same in both instances (Fig. 4).

When *cobefrin* and *epinephrine* were given orally while the animal was under general anesthesia.—The animals were anesthetized with sodium amytal, and the blood pressure in the femoral arteries was taken in the usual manner. *Cobefrin* (2 mg. for each kg. of body weight) was mixed with physiologic saline solution and placed in the stomach by means of a small rubber tube. A definite pressor response was obtained in one and a half minutes. The blood pressure increased gradually and subsided slowly after having remained slightly elevated for almost thirty minutes. A similar dose of *epinephrine* did not produce any effect on the blood pressure (Fig. 5). Herein lies one distinct difference between *epinephrine* and *cobefrin*; *cobefrin* is active when administered orally, while *epinephrine* is not.

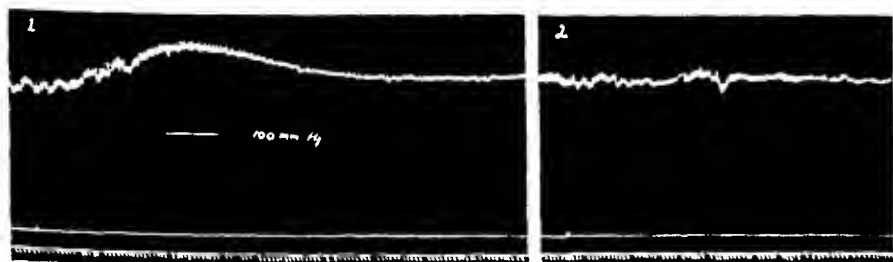


Fig. 5.—The effect on the blood pressure of the oral administration of (1) 2 mg. of *cobefrin*, and (2) 2 mg. of *epinephrine*; weight of the dog was 8 kg.; no increase in the blood pressure was produced by *epinephrine*.

ACTION OF COBEFRIN AND EPINEPHRINE ON THE ISOLATED HEART OF THE RABBIT

The heart was perfused at a temperature of 37.5°C ., according to the method of Locke and Rosenheim. The addition of 0.25 mg. of *cobefrin* to the perfusion fluid (500 c.c.) caused a rapid increase in the rate of the heart. Within three minutes after the addition of the *cobefrin*, the rate of the heart had increased from 136 beats a minute to 148 beats a minute, and within seven minutes, the rate was 183 beats a minute. Associated with this tachycardia, there was a slight decrease in perfusion flow from 36 c.c. a minute to 29 c.c. a minute. The increase in the rate of the heart continued for an hour and a half before the rate returned to the control figures. A second injection of *cobefrin* was given an hour and forty-five minutes after the first. This produced similar results (Table I).

A dose of 0.05 mg. of *epinephrine*, which was also added to the perfusion fluid, produced a definite tachycardia, but no change in per-

Numerous attempts to isolate from the crude epinephrine a principle which contained no epinephrine or other pressor substance, but which produced cardiac slowing, were unsuccessful. Another observation worthy of note is the not infrequent occurrence of evidence of cardiac slowing, vagal or otherwise, when eobefrin is given to an animal following a previous injection of commercial epinephrine. It was impossible to explain this phenomenon. Interesting also is the fact that administration of equal mixtures of commercial epinephrine and eobefrin produce a blood pressure curve which is a combination of the curves produced by each substance separately. Cortical extract (cortin) given intravenously (1 c.c. to a dog weighing 16 kg.) did not produce any increase in blood pressure on several occasions.

While the animal was under local anesthesia.—A 2 per cent solution of pantocain was used to infiltrate the tissues around the femoral artery. The blood pressure then was recorded in the usual manner by

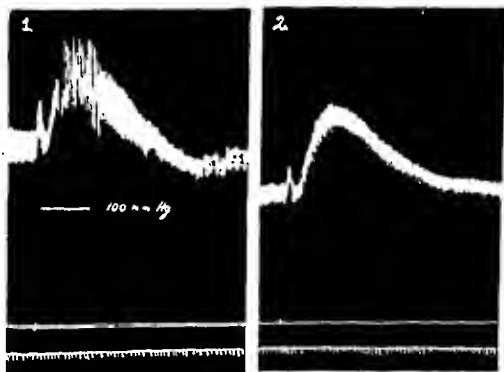


Fig. 4.—The effect on the blood pressure of an intravenous injection of 1.2 mg. of eobefrin (1) previous to hepatectomy, and (2) after hepatectomy; weight of the dog was 24.7 kg.

means of cannulation. Little difference was apparent between the pressor effects under general anesthesia and those under local anesthesia, except that the increase in blood pressure which followed the administration of epinephrine or eobefrin was not as marked under local anesthesia as it was under general anesthesia. Eobefrin again showed a slightly more prolonged action.

Before and after hepatectomy.—This experiment was performed on an animal which weighed 24 kg., after the first two steps in the technique of hepatectomy had been performed. The dog was anesthetized with ether, and the record of the blood pressure was taken by means of a cannula in the femoral artery. At the same time, 1.2 mg. of eobefrin was given intravenously. The animal was then operated on again, and the liver was removed. Shortly after hepatectomy, the same dosage of eobefrin was repeated, and another tracing was taken of the response of the blood pressure. There is little significant difference in

oxygenated Ringer-Locke solution at a temperature of 37.5° C. The addition of 0.05 mg. of cobefrin to 50 c.c. of water in a water-bath which contained a rhythmically contracting uterus, produced practically immediate cessation of activity. This quiescent period usually lasted from five to eight minutes. In comparison, cobefrin is just as effective in producing this response as is epinephrine.

ACTION OF COBEFRIN ON THE LUNGS

Closely allied to the action of cobefrin on the smooth muscle of the uterus or intestine is the well-known action of epinephrine in alleviating bronchospasm which may be the result of an allergic condition or which may be produced experimentally with histamine. Several guinea pigs (average weight 0.5 kg.) were given 0.15 mg. of histamine intravenously; this produced severe bronchospasm in each animal. All of the animals in the control group died; of those that were given 0.1 c.c. of 1 to 1,000 solution of epinephrine, all but two survived. The technical difficulty in giving the solution of epinephrine intravenously accounted for delay in its administration and the resultant death of the two animals.

After producing bronchospasm in another group of animals with histamine, 0.5 c.c. of a 1 to 1,000 solution of cobefrin was given, and the bronchospasm was relieved in the same manner as it was by the administration of 0.1 c.c. of a 1 to 1,000 solution of epinephrine. Likewise, in this experiment, all of the control animals died, while there was only one death among those which had received cobefrin. The average duration of the bronchospasm following the administration of either epinephrine or cobefrin was four minutes, and then recovery occurred. The average length of time before death occurred in the animals which did not receive epinephrine or cobefrin was two and a half minutes.

Bronchospasm of guinea pigs that is produced by administration of histamine or by sensitization to foreign protein (2 per cent solution of egg white) could be relieved as efficiently with the intravenous administration of epinephrine as it could with intravenous administration of cobefrin. When either one is given intramuscularly or subcutaneously, however, the absorption is too slow to relieve the bronchospasm, and the animals die before the action of the drug takes place.

SITE OF DESTRUCTION OF EPINEPHRINE AND COBEFRIN IN THE BODY

Elliott, in 1905, said that the general capillary bed in the entire animal body serves as a site of elimination or destruction for epinephrine, with one exception, namely, that of the lungs. It is not possible to demonstrate by perfusion any loss of epinephrine in these

TABLE I

ACTION OF COBEFRIN ON THE ISOLATED RABBIT HEART

TIME	HEART			TIME	HEART			
	RATE PER MINUTE	OUTPUT, C.C.			RATE PER MINUTE	OUTPUT, C.C.		
		PER MINUTE	IN FIVE MINUTES			PER MINUTE	IN FIVE MINUTES	
9:27 A.M.	145	36.4		11:06			120	
9:29	140			11:09			146	115
9:30				11:12				
9:34	138			11:14			148	
9:36	134			11:18				110
9:40	137			11:23			158	
9:45	130			11:27			154	
9:47	144			11:31			148	90
9:50	142			11:41			130	70
9:53	140			11:50			134	70
9:57	138	11:52	134					
10:00	138	11:55	132	68				
10:02	138	178	12:00 M.					
10:14	136		12:01 P.M.	128				
10:15*			12:04	134		60		
10:16	137		12:07	142				
10:18	148		12:09	153	14.5	72		
10:22	183	170	12:10	166				
10:24	183		12:13	157				
10:25		168	12:16	167		68		
10:27	174		12:20	158				
10:29	172		12:23	146				
10:30	168		12:26	149		60		
10:31		162	12:28	142				
10:34	174		12:30	144				
10:35	180		1:50	136		56		
10:36	178		1:55	132				
10:38		148	1:57†					
10:41	170		1:59	128				
10:42	164		2:00	160		58		
10:44		140	2:02	162				
10:47	162	26.0	2:03	170	15.7	55		
10:47	158		2:05	164				
10:50		130	2:08	160		56		
10:51	156		2:10	155				
10:54	154		2:12	150		54		
10:55	152	128	2:20	145				
10:56	148		2:25	140				
11:00								

*0.25 mg. cobefrin added to the perfusion fluid.
†0.05 mg. epinephrine added to the perfusion fluid.

fusion flow. The duration of the increase in the cardiac rate was shorter after the addition of epinephrine than it was after the addition of cobefrin. This may be attributed to fatigue, however, since the preparation had been operating for more than three and a half hours. When a fresh preparation is used epinephrine usually causes an increase in cardiac rate and perfusion flow.

ACTION OF COBEFRIN ON THE ISOLATED UTERUS OF THE VIRGIN GUINEA PIG

Since it is well established that epinephrine usually produces relaxation of isolated smooth muscle, cobefrin was studied for comparison. A small strip of the uterus of a guinea pig was perfused with an

added to the venous reservoir. The blood flow from the liver was measured periodically during the experiment to determine the variation in quantity during and following the activity of cobefrin. The blood pressure and pulse rate were likewise recorded at intervals. Samples of the perfused blood (10 c.c.) were taken intermittently during the course of the experiment for testing. A dog which weighed 5.5 kg. was used for the test. The data in this experiment are correlated in Table II.

Testing of specimens of blood.—Specimens of blood which had perfused through the heart-lung-liver preparation for one, two, and three hours gave practically identical pressor responses in the test animal, which indicated that very little, if any, of the cobefrin had been destroyed after the first hour of perfusion. Other specimens, which were taken twelve, twenty-three, and thirty-four minutes after the addition of cobefrin, showed a progressive decrease in the amount of pressor response, but the maximal destruction of the drug occurred within an hour, and subsequent specimens failed to indicate any further progression in its elimination (Fig. 7).



Fig. 7.—The effect on the blood pressure of successive injections of 10 c.c. of blood which contained approximately 0.015 mg. of cobefrin per c.c. previous to perfusion through the heart-lung-liver preparation: (1) before perfusion, (2) after perfusion for twenty-three minutes, (3) after perfusion for thirty-four minutes, (4) after perfusion for one hour, (5) after perfusion for three hours.

There is considerable reduction in the blood flow from the liver after the addition of cobefrin to the perfusion fluid; however, the duration of the constriction is usually not more than a fourth to a fifth of that seen in the heart-lung-hindlimb perfusion experiment which will be described next. It was the rule that, within three to five minutes after the introduction of cobefrin into the heart-lung-liver preparation, the return blood flow from the liver was reduced 80 per cent from control figures. This diminished return of blood from the liver endured for approximately twelve minutes.

From the results of the heart-lung-liver perfusion experiments, it was not possible to determine whether or not the liver was specific for the elimination of cobefrin. In order to ascertain whether any large capillary bed in the body would produce the same responses as those obtained with the heart-lung-liver preparation, the hind limbs were used in circuit with the heart-lung preparation.

organs. In order to determine whether the lungs played any significant part in the elimination or inactivation of cobefrin, experiments with the Starling heart-lung preparation were carried out.

Heart-lung perfusion experiment.—Routine preparation of a dog weighing between 10 and 12 kg. was made under ether anesthesia, and 1.0 to 1.5 liters of blood obtained from healthy dogs were added to the venous reservoir of the perfusion apparatus. Fifteen mg. of cobefrin were introduced into the venous reservoir after a control sample of 5 c.c. of blood had been taken for analysis. On the addition of cobefrin, the cardiac rate was rapidly accelerated, and this acceleration was maintained for two to two and a half hours. Samples of blood were taken at varying intervals from the venous reservoir for three and a half hours. These were tested along with the control blood by determining the effect on the blood pressure of a small dog which weighed 6 to 8 kg. The test animals in all perfusion experiments were anesthetized with sodium amytal (50 mg. for each kg. of body weight). The results of

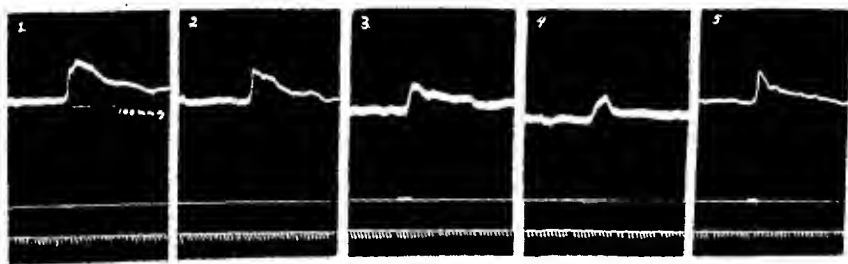


Fig. 6.—The effect on the blood pressure of successive injections of 5 c.c. of blood which contained approximately 0.01 mg. of cobefrin per c.c. previous to perfusion through the heart-lung-hindlimb preparation: (1) before perfusion, (2) after perfusion for thirty minutes, (3) after perfusion for one hour, (4) after perfusion for two hours, (5) after perfusion for three hours; there was no appreciable change in the response of the blood pressure after the blood had perfused for one, two, and three hours.

this test indicated that in several experiments practically none of the cobefrin had been destroyed or inactivated by the heart-lung perfusion (Fig. 6).

Since it has been demonstrated that the liver has the ability to inactivate, detoxify, and destroy many substances, among which are nicotine and strychnine,¹² we attempted to ascertain if hepatic tissue could change or affect the pressor properties of cobefrin. Markowitz and Mann, in their study on the destruction of epinephrine in the body, showed that it disappears in practically all of the tissues of the body, and that no organ or viscus is specific for its elimination.

Heart-lung-liver perfusion experiment.—A dog weighing 8 kg. was used for this experiment. One liter of blood was obtained from a healthy dog to augment the supply of blood in the venous reservoir. After routine preparation of the animal, cobefrin in a concentration of 0.015 mg. for approximately each c.c. of circulating blood was

isolated, and ligatures were put in place in readiness for insertion of a cannula. The aorta was cannulated and received blood from the arterial side of the heart-lung preparation, and a similar insertion of a cannula into the inferior vena cava permitted the return of the blood to the venous reservoir.

Following these procedures, the limbs were rapidly isolated from the animal, and hemostasis was effected by ligatures. When the preparation was in equilibrium, cobefrin in a concentration of approximately 0.015 mg. for each c.c. of circulating blood was added to the arterial side of the circuit, the total dose being 15 mg. There was immediate cardiac acceleration, but within three minutes after the injection, the return flow from the hind limbs was reduced to one drop each second. This extreme vasoconstriction which was induced by cobefrin prevented perfusion of the limbs to any reasonable degree, and for almost an hour the blood was shunted into the venous reservoir while the preparation operated on a straight heart-lung per-

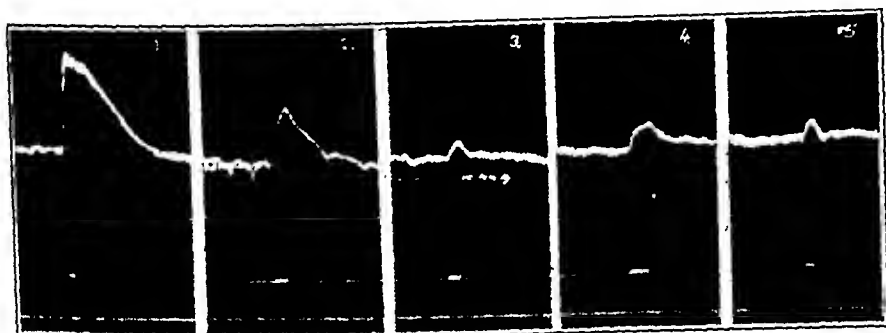


Fig. 8.—The effect on the blood pressure of successive injections of 10 c.c. of blood which contained approximately 0.015 mg. of cobefrin per c.c. previous to perfusion through the heart-lung-hindlimb preparation: (1) before perfusion, (2) after perfusion for twenty-five minutes, (3) after perfusion for forty-five minutes, (4) after perfusion for two hours, (5) after perfusion for three hours.

fusion (Table III). At the end of an hour the constriction became less and the venous flow from the limbs gradually increased. In comparison with the constriction noted in the liver perfusion, the hind limbs were constricted an hour longer. According to the same procedure in previous experiments, specimens of blood (10 c.c.) were taken from the venous reservoir and were tested on a dog weighing 8 kg., by noting the effect on the blood pressure (Fig. 8).

The pressor effect of a three-hour specimen of blood from the venous reservoir showed a slight increase in the blood pressure which was moderately sustained. A specimen of blood that had perfused for two hours gave a definite pressor response very similar to that of the three-hour sample. The injection of blood that had perfused for twenty-five minutes produced a marked increase in blood pressure, and the duration of the pressor effect was somewhat longer than that

TABLE II
HEART-LUNG-LIVER PERFUSION EXPERIMENT

TIME	BLOOD FLOW FROM LIVER, C.C. PER MINUTE	PULSE RATE, PER MINUTE	SYSTOLIC BLOOD PRES- SURE, MM. OF MERCURY	REMARKS
10:20 A.M.			140	Control
10:24	175	140	140	
10:27	195	124	130	
10:29	215	126	130	
10:31	218	126	120	
10:33	220	126	120	
10:35	225	126	120	
10:42	225	128	120	15 mg. eobefrin added
10:45	125	190	118	Marked reduction in flow of blood from liver and in- crease in rate of heart
10:47	100	190	116	Blood pressure falling
10:50	100	190	115	
10:54	120	190	115	Blood flow from liver increas- ing
10:58	125	190	115	
11:01	140	188	115	Steady increase in blood flow from liver
11:04	150	188	115	
11:08	155	186	110	Decrease in rate of heart
11:12	185	180	110	
11:15	210	180	110	
11:19	240	180	110	
11:23	260	180	110	
11:25	280	180	100	Gradual decrease in blood pres- sure
11:28	300	180	100	
11:32	325	180	100	
11:34	350	180	105	
11:42	350	180	100	
11:48	400	180	75	Marked increase in blood flow from liver
11:53	380	182	70	
12:00 M.	345	182	70	Gradual decrease in blood flow from liver
12:04 P.M.	350	190	65	Increase in rate of heart
12:06	348	190	70	
12:08	335	190	72	
12:10	325	180	72	Cardiac rate decreasing
12:18	310		70	
12:28	305	170		
12:30	280		70	
12:35	280	170	70	
12:38	285		70	
12:42	280		70	
12:45	275			
12:47	260	140	60	
1:00	250	136	58	
1:12	215	134	60	
1:16	215	134	60	
1:27	205	130	58	

Heart-lung-hindlimb perfusion experiment.—The routine heart-lung preparation was made. In another animal, which weighed approximately 4.5 kg. and was under amytal anesthesia (50 mg. for each kg. of body weight) the abdominal aorta and inferior vena cava were

amounts of cobefrin provided an interval of from one to two hours has elapsed between the injections. When the interval is less than one hour, further addition of cobefrin does not affect the vasoconstriction which is still present, nor does it increase the cardiac rate. At the termination of the experiment the skeletal muscles of the limbs were examined and were found to be in excellent physiologic condition; there was no evidence of rigor, and the muscles responded vigorously to stimulation by the indnetorium set at 8 cm.

Examination of specimens of blood obtained from the hind limbs indicated that the capillary bed of the liver. Within thirty to forty minutes destroying cobefrin as that of the liver. Protracting the experiment to three and four hours resulted in very little, if any, further elimination of the drug, as determined by response of the blood pressure of the test animal.

HYPERGLYCOGENIC ACTIVITY OF COBEFRIN

It is known that the injection of epinephrine, pituitrin, or thyroxin causes hyperglycemia by a rapid mobilization of glycogen in the liver, and that these substances, especially epinephrine, are more effective in a well-fed animal than they are in a fasting or diabetic one. The fact that an animal in a rather poor state of nutrition, with a persistently low value for the blood sugar responds poorly to administration of epinephrine is shown in the following experiment which we carried out.

A dog weighing 16 kg. was not fed for twenty-four hours and then was given 0.6 c.c. of 1 to 1,000 solution of pure epinephrine and 10 c.c. of physiologic saline solution intravenously. Specimens of venous blood were taken at intervals during a two-hour period, and the respective values for the sugar were determined. It is clear from the results of this experiment that there was a negative response to epinephrine in this animal as the values for the sugar did not deviate significantly from control values.

The same animal one week later, after it had been fed milk and sirup in addition to its regular diet in the interim, was again allowed to fast for twenty-four hours prior to another injection of 0.6 c.c. of 1 to 1,000 solution of epinephrine. The values for the blood sugar in these two experiments are shown in Table IV.

A comparative study of the activity of epinephrine and cobefrin was made on several animals. In all instances, both drugs were given to the same animals, but each drug was given on a different day. The dogs used were in good condition and were permitted to fast for only twenty-four hours prior to the determination of the blood sugar. An intravenous injection of 0.6 c.c. of epinephrine when given to a dog

obtained with the other specimens. It was thought at first that this might be attributable to a stasis in the circulation through the limbs which was caused by the severe constriction of the vessels. Consequently, the scanty venous return would contain a greater concentration of eobefrin than would otherwise be found. It might also be attributable to the short duration of the perfusion which did not allow the capillary bed of the limbs to eliminate as much of the pressor substance as it did in two and three hours.

TABLE III
HEART-LUNG-HINDLIMB PERFUSION EXPERIMENT

TIME	VENOUS RETURN, C.C. OF BLOOD PER MINUTE	SPECIMENS TAKEN FOR TESTING; REMARKS
12:00 M.	130	Specimen (10 c.c.) for control
12:12 P.M.	135	15 mg. eobefrin added to arterial circuit
12:15	5	Marked reduction in venous return
12:22	4	
12:27	6	Specimen 1 (10 c.c.); perfusion for fifteen minutes
12:31	10	Blood very venous
12:42	14	Specimen 2 (10 c.c.); perfusion for half an hour
12:55	20	
1:12		Specimen 3 (10 c.c.); perfusion for one hour
1:25	48	
1:30		Oxygen introduced into venous reservoir
1:36	64	
1:42	85	Specimen 4 (10 c.c.); perfusion for an hour and a half
1:51	110	
2:00	120	
2:09	135	
2:12	135	Specimen 5 (10 c.c.); perfusion for two hours
2:14	133	
2:17	132	
2:18	134	15 mg. eobefrin added
2:20	25	Marked reduction in venous return
2:28	22	
2:46	14	Specimen 6 (10 c.c.); perfusion for two and a half hours.
3:00	20	15 mg. eobefrin added
3:12		No further reduction in venous return

In view of the fact that there was such a marked vasoconstriction in the tissues of the hind limbs, several other preparations were made and eobefrin was added slowly in graduated amounts to the arterial side of the perfusion circuit. We anticipated that small doses of eobefrin added at intervals would eliminate the intense degree of constriction and thus allow the limbs to carry on the perfusion more satisfactorily. Unfortunately, this did not hold true. In one experiment, practically identical with the one just described, with animals which were approximately the same size, we added slowly 5 mg. of eobefrin instead of 15 mg., but in spite of the smaller dosage the same marked vasoconstriction occurred. The perfused tissue responds to additional

amounts of cobefrin provided an interval of from one to two hours has elapsed between the injections. When the interval is less than one hour, further addition of cobefrin does not affect the vasoconstriction which is still present, nor does it increase the cardiac rate. At the termination of the experiment the skeletal muscles of the limbs were examined and were found to be in excellent physiologic condition; there was no evidence of rigor, and the muscles responded vigorously to stimulation by the inductorium set at 8 cm.

Examination of specimens of blood obtained from the hind limbs indicated that the capillary bed of the limbs was just as effective in destroying cobefrin as that of the liver. Within thirty to forty minutes the hind limbs had removed nearly all of the cobefrin which they were capable of removing. Protracting the experiment to three and four hours resulted in very little, if any, further elimination of the drug, as determined by response of the blood pressure of the test animal.

HYPERGLYCOGENIC ACTIVITY OF COBEFRIN

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TABLE IV
HYPERGLUCOGENIC ACTIVITY OF EPINEPHRINE

IN DOG WITH CONSTANT LOW VALUE FOR BLOOD SUGAR		IN DOG WITH CONSTANT HIGH VALUE FOR BLOOD SUGAR	
SPECIMENS OF BLOOD	MG. OF SUGAR PER 100 C.C. OF BLOOD	SPECIMENS OF BLOOD	MG. OF SUGAR PER 100 C.C. OF BLOOD
Control	76.0	Control	125.0
10 minutes after injection	80.0	10 minutes after injection	190.5
20 minutes after injection	89.0	20 minutes after injection	161.3
30 minutes after injection	85.6	30 minutes after injection	142.8
1 hour after injection	72.0	1 hour after injection	148.0
2 hours after injection	74.3	2 hours after injection	130.7

weighing 16.0 kg. produced a rapid increase in the value for the blood sugar from a central value of 63 mg. for each 100 c.c. of blood to 112 mg. within ten minutes. The same dog three days later, after having been given 0.6 c.c. of cobefrin intravenously, showed an increase in the central value from 65 mg. of sugar for each 100 c.c. of blood to 135 mg. within ten minutes. Essentially there is little difference in the degree of increase in the blood sugar produced by cobefrin and epinephrine, and the onset and duration of the effects of the two drugs are practically identical. Within one hour after the injection of either epinephrine or cobefrin, the value for the blood sugar returned to control values (Fig. 9).

SUMMARY

In this comparative study of cobefrin and epinephrine, it has been shown that these two substances have many properties in common, and that, for the most part, their physiologic behavior is identical. There are, however, several differences which are noteworthy. Both substances produce similar increases in the blood pressure of test animals, with the exception that the activity of cobefrin generally endures slightly longer than that of epinephrine. The duration of the pressor response produced by comparable doses of cobefrin is midway between that of epinephrine and ephedrine. Epinephrine causes a more marked but shorter pressor response than does ephedrine. Cobefrin gives the same abrupt pressor response as does epinephrine; the pressor response of cobefrin lasts longer than that of epinephrine, but does not endure as long as that of ephedrine.

Barger and Dale pointed out that the maximal pressor activity of epinephrine and allied compounds was dependent on the introduction of hydroxyl groups on the para and meta positions in the basic benzene ring. Ephedrine does not have these hydroxyl groups, which probably accounts for the fact that it has less vasopressor activity.

The presence or absence of vagal reflexes during the studies of the effects of epinephrine and cobefrin on the blood pressure were not

constant in occurrence under any type of anesthesia. As a rule, neither substance gave evidence of a reflex vagal slowing with a concomitant decrease in the blood pressure. The advantage which a few clinical investigators have claimed for cobefrin is that it does not produce reflex vagal slowing of the heart. This finding was substantiated. The results which were obtained with commercial epinephrine were comparable with those obtained with cobefrin. Consequently, the use of cobefrin instead of epinephrine would appear to have no advantage in this respect. One outstanding and important difference between these closely allied compounds is that cobefrin is

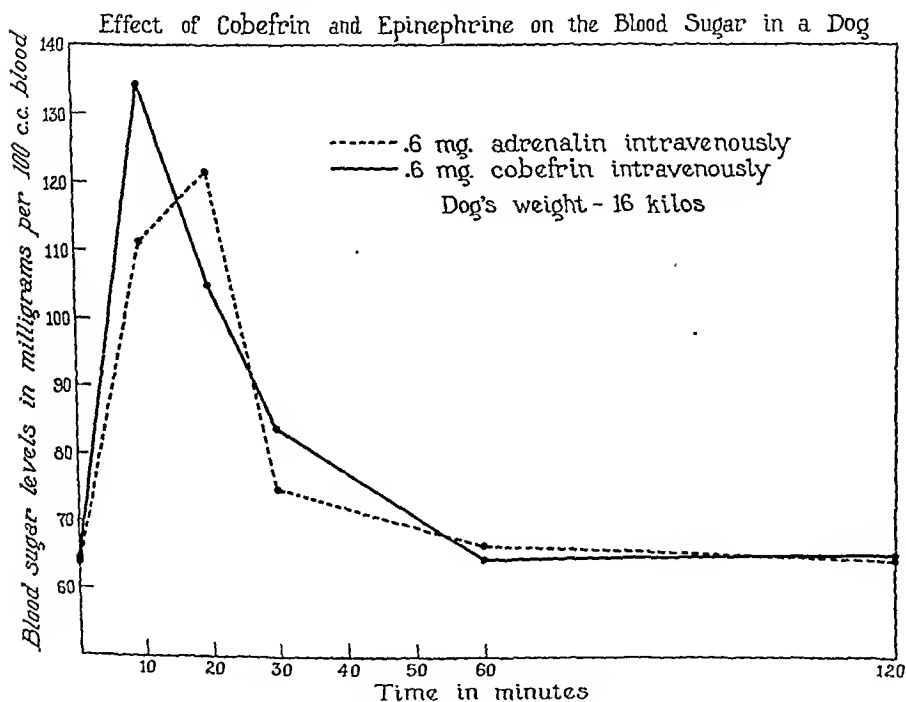


Fig. 9.—The effect of cobefrin and epinephrine on the blood sugar of a dog.

active when administered by mouth while epinephrine is not. Herein lies the one major difference in the action of these two substances.

Cobefrin was found to be just as effective as epinephrine in stimulating the perfused isolated heart of the rabbit, and the ability of cobefrin to cause relaxation of a rhythmically contracting uterus of a virgin guinea pig or to relieve bronchospasm was identical with that of epinephrine. To determine the site of destruction of cobefrin in the body, the Starling heart-lung, heart-lung-liver, and heart-lung-hindlimb perfusion preparations were employed. It was found that practically none of the cobefrin was inactivated in the heart-lung perfusion experiments, which fact coincides directly with the results of

Elliott's experiments with epinephrine. However, the heart-lung-liver and the heart-lung-hindlimb perfusion experiments indicated definitely that any large capillary bed, with the exception of that of the lungs, serves as a site for the elimination of cobefrin. The liver is by no means as specific an organ for the inactivation of cobefrin as it is for the inactivation of nicotine or novocain. Studies on the blood sugar of dogs showed that epinephrine and cobefrin were equally potent in producing definite increases in the values for the blood sugar, provided the animals were in a proper state of nutrition.

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A SUGGESTION IN THE TECHNIC OF CHOLECYSTECTOMY FOR THE COMPLICATED CASE OF GALLBLADDER DISEASE

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IN 1909, the late Dr. Archibald MacLaren and I, through his courtesy, reviewed 165 operations on the gallbladder, liver, and pancreas. I note this dusty datum from the archives to repeat a statement made in that paper which is pertinent to this discussion: "*It was found necessary to remove the gallbladder in twenty-one cases.*" Three patients died, one in seven, a mortality of 14.2 per cent.

The surgeon whose experience and study revert to the first decade of this century will support the statement that there was at that time an active discussion of the relative merits of cholecystotomy and drainage, and cholecystectomy, revolving in the main about the question of mortality. (Among the many distinguished surgeons of that period appear the names of Mayo-Robson, Moynihan, Deaver, Maurice Richardson, Murphy, and Mayo.) In 1904, Mayo-Robson reported twenty-eight cases of cholecystectomy; four patients died, one in seven—a mortality of 14.2 per cent. He remarked about the possible increase in mortality when cholecystectomy was attempted. Moynihan was definite in his opinion that every cystic gallbladder should be removed, but stated that in carefully selected cases, the mortality following cholecystectomy should be no larger than in cholecystotomy. In various other reports, the mortality following cholecystectomy ranged from 25 per cent in the French literature, to the report of Mayo of less than 2 per cent in five hundred operations. Through all that period the caution was given that the mortality may be increased by the attempt to remove the organ, leading up to the dictum of Deaver, "when in doubt, drain."

The technical phases of the operation of cholecystectomy gradually received more attention. There was an active debate, which continued over several years, upon the relative feasibility of the up-down or the down-up method of procedure. It was the demonstration of the down-up, or the so-called reverse, method of removal that stimulated the attempt to perform cholecystectomy in a larger group of cases, those instances in which a pancreatitis was demonstrated or suspected being, of

course, excepted. In these cases, the gallbladder was purposefully left to insure drainage of the biliary system as a part of the treatment for the inflammation in the pancreas.

There is no keener procedure in surgery than that wherein the cystic duct and artery are positively identified, ligated under the sense of sight and touch, the liver attachments severed by the cut-and-sew method, with the last step of the operation, the tying off of the gallbladder at the liver notch, with the removal of the disease and the whole field completely repaired. Whereas at the beginning, cholecystectomy was used only in case of gross pathology, the accumulated experience and reports of success led to the operation in cases of mild pathology—the white-walled and the strawberry gallbladder. There were also those who advocated cholecystectomy on a purely symptomatic basis. Over the years the accumulated evidence indicates, and I think it is the general consensus of opinion, that the prime object of surgical attack on the gallbladder is its removal and that a failure to do so yields a sense of defeat in the performance of incomplete operation.

There are conditions, however, wherein the attempt at formal excision carries with it a risk of an operative misstep, a stormy convalescence, or a fatality. That such events do occur is witnessed by the ingenuous plans in the literature for the reconstruction of the common duct, the not infrequent reports of secondary operations where conditions are found producing symptoms which may fairly be placed on a technical basis. Mortality statistics of individual surgeons and special clinics show a satisfactory improvement, but recent interesting and important surveys of general clinics, where the work of many surgeons is included, indicate that the average result of operations in this field carries a mortality which is still somewhere between 3 and 4 per cent. Add conditions outside the operative field—the obese patient, incomplete exposure, inadequate relaxation of the fighting anesthesia, the aged and debilitated patient, hypertension—all these conditions and others in which the time element of the operation may be a factor in recovery may accumulate to a point where this suggested technic may have a wider application than I care to indicate and sponsor at this time. When the landmarks are clouded, when the excision carries a risk of injury to the structures about the gallbladder, when the integrity of the gallbladder wall is uncertain, I suggest this technic be considered.

To illustrate the procedure, I have resurrected an illustration now buried twenty-seven years (Fig. 1). This old plate (originally in color), showing impacted stones in the cystic duct, may not represent an unusual condition. I will say that in some of the cases operated upon by this plan, it has been a revelation to note the narrow margin of safety that the surgeon assumes in attempting cholecystectomy, whenever the base

of the gallbladder has folded over the common duct, the common duct the site of inflammatory change, or the cystic duct widely dilated. If one will visualize the large cystic, or the small contracted, gallbladder, the first step (Fig. 2a) is to split the wall so that the resulting wings are equidistant from the attachments to the liver. This incision is carried down, until the cystic duct is demonstrated from within. The extent of this incision lies within the judgment of the operator; I believe it should be limited to a definite margin of safety. The second step (Fig. 2b) is to "wing" the gallbladder by two opposed symmetrical incisions carried down to a point decided upon in the separate case, but still within a margin of safety. The "wings" are completely removed. The two steps concluded leave a strip of the gallbladder wall and mucous membrane wide enough to completely preserve the normal attachments



Fig. 1.—The cut resurrected from the article of twenty-seven years ago is shown. In the situation of impacted stones in the cystic duct, this plan of cholecystectomy would not be complete, but it would clearly demonstrate the condition. (Fig. 2, Surg., Gynec. & Obst. 8: 337, 1909.)

to the liver. In trying to find a comparison of this situation to some common resemblance, I would suggest that it looks like a ladle, the handle of which is the strip on the liver, and the cup, the mucous membrane lined base of the gallbladder. I think it worth while to keep this comparison in mind, because the success of the operation depends upon the achievement of the next step. The third step (Fig. 2c) is the careful dissection of the mucous membrane of the handle and the cup. The line of cleavage between it and the wall is readily found at the liver notch. Every effort is made to preserve the continuity of the mucous membrane of the handle, in order to lead to line of cleavage between the mucous membrane and the wall of the cup. This latter excision may be exacting. In one case, the tissues were so friable that all I could do was to

curette this pocket in the hope of a complete removal of the mucous membrane. In another case there was a note of uncertainty of its complete removal. Unless this step is complete, the procedure lines up with those cases wherein the amputation has been made above the cystic duct, leaving a part of the gallbladder in situ, a condition which invites the re-formation of the gallbladder, so well described by Beye.

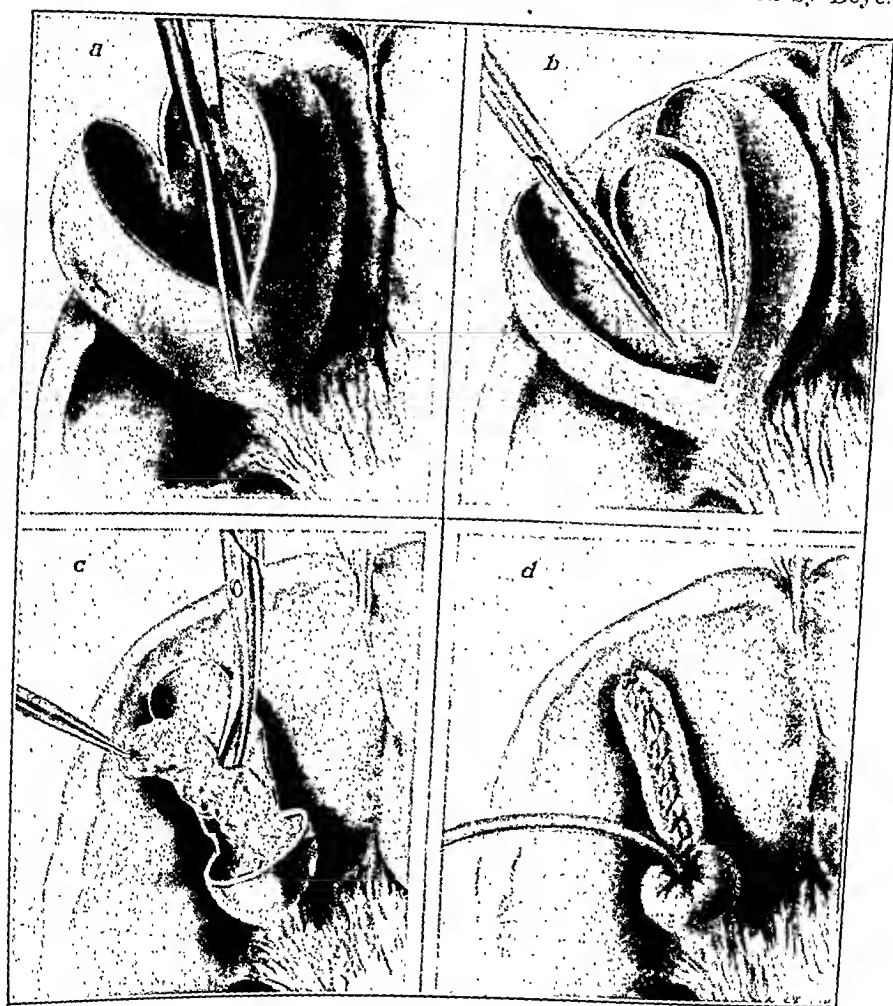


FIG. 2.—*a* and *b*. These incisions should be carefully and symmetrically made to avoid confusion of direction and extent. *c*. I asked Miss Hirsch of the Art Shop to make the picture of the ladle diagrammatic. The surgeon will visualize all sorts of combinations of width of handle and depth and irregularities of the cup. I think enough of the handle should be left to insure its suture into a cord and enough of the cup be left to allow suture about the drainage tube. I suggest the surgeon try out the dissection of the mucous membrane on those cases where the gallbladder had been removed by formal methods. *d*. It has been suggested that the tube be brought up through the handle. So far this has not been done.

The fourth step is the suture of the wall of the ampulla around a tube, and the continuation of the suture up the gallbladder wall still

adherent to the liver, in order to cover, or at least diminish in size, denuded surfaces and control bleeding.

The first objection to such a procedure is that in opening the gallbladder so widely, infectious agents are released upon the peritoneum. In this group of selected cases, the peritoneum is often involved, as shown by adhesions, and the absorbability of the peritoneum thereby is lessened. It is an established fact that the clean peritoneum will withstand gross insult with recovery, provided the time element of the irritation has not been carried over too long a period. In this case, the area is immediately drained. I have been deeply impressed by the studies of Andrews on the infectious nature of the gallbladder contents, even to the point of questioning the appropriateness of the term "empyema" of the gallbladder. I believe his studies fit with my clinical observations of such conditions. However, this is a valid objection which the surgeon must balance on the question of leaving the gallbladder with drainage on the one hand, or the attempt to remove it by formal methods under difficult and dangerous circumstances, on the other.

The second objection is that some of the gallbladder wall is left in situ. Andrews indicates that infection resides in the wall. From a clinical standpoint, this objection is of negligible worth.

The third objection is the one which has deterred me from saying anything about the plan to anyone except those in my immediate contact. This objection is that the procedure must be classed as crude, bizarre, trick surgery, which offends one's sense of propriety, when it is compared to the ideal methods. Yet I believe the operation is founded on proper surgical principle in that the mucous membrane lining is removed. Clinically it is not the wall that is often at fault, but the mucous membrane, which by its structure tends to continue its function of secretion even under the most extraordinary and adverse conditions. The procedure is comparable to that used in inflammatory ovarian cysts, in which the formal removal of the tumor was impossible, but which yielded results when the mucous membranes were removed with collapse and atrophy of the wall.

My first operation was done in 1921, without premeditation and under a sense of desperation to do something to a ragged, friable gallbladder, to complete the operation, and to get a sick patient to bed, where she was placed with an expectation of a fatality. The convalescence in this case was so free from concern that I began to wonder whether the procedure were not acceptable. The second case was a man, whom we had observed over several years, with persistent hypertension of systolic 260, diastolic 130. He developed a tumor mass in the right upper quadrant with symptoms imperative of relief. He was the first patient in whom this procedure was deliberately selected. The gallbladder was removed, as above described, with less concern than often follows the ordinary case. The man lived for several years to die of apoplexy.

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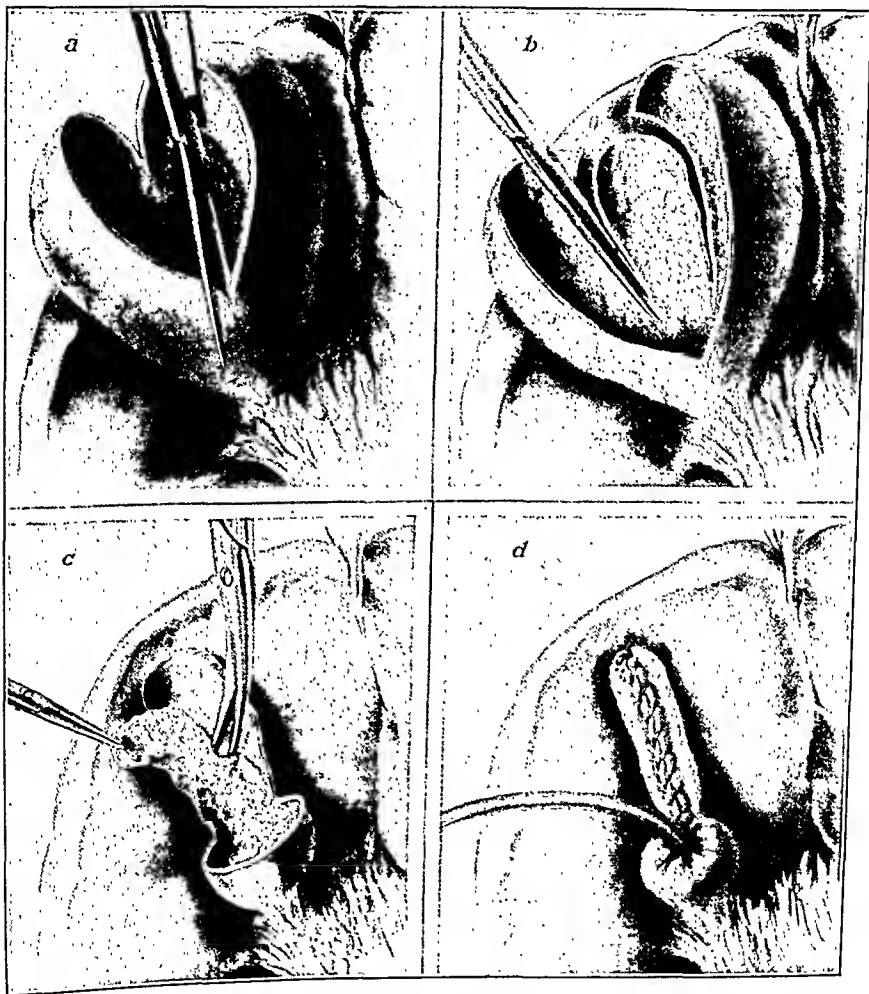


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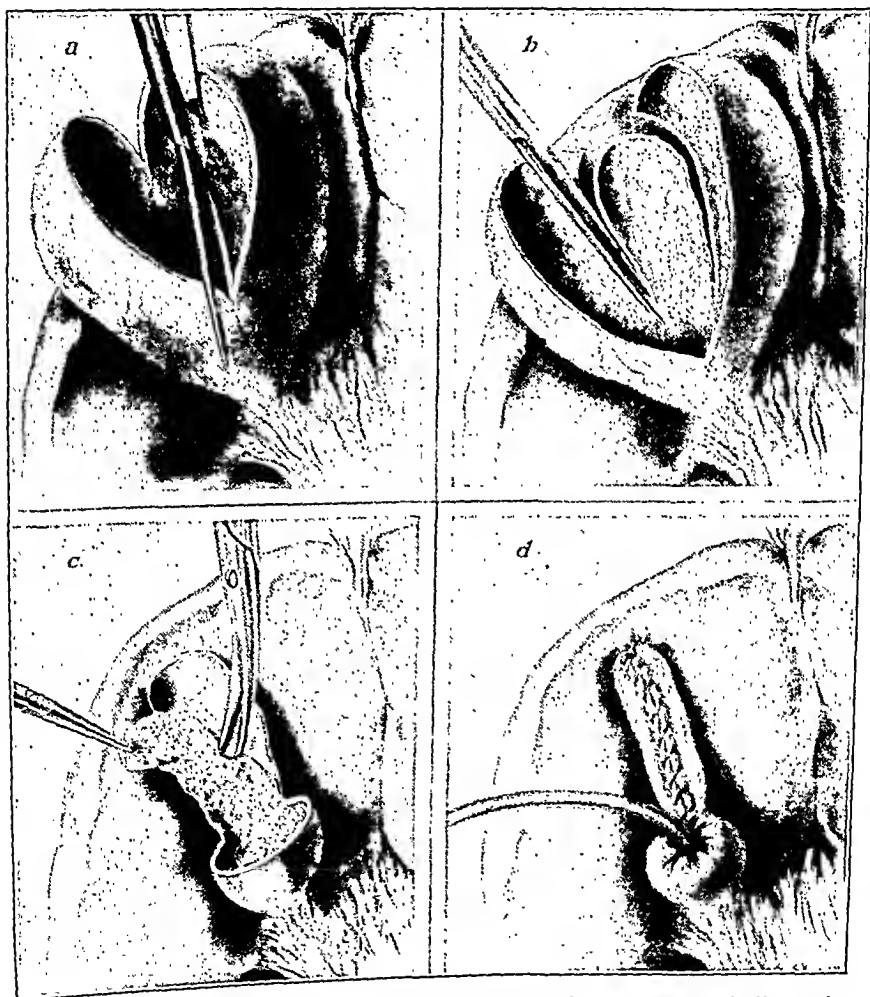


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In the literature, there are many valuable and practical suggestions and procedures other than the formal down-up and up-down methods of attack on the gallbladder—electrocoagulation, subserous cholecystectomy—and I feel sure that every surgeon must, at some time or other, have found it necessary to substitute or add steps to meet special conditions. My feeling is that should the above plan be the same or similar to any such of your steps, then I simply suggest it support these steps. I have no desire to offer anything new, but to present a plan of an emergency nature, a way out of the complicated cases, and to exclude the risks of injury to the common duct and particularly to the liver. It might interest you to scan that old article of twenty-seven years ago and read it in the light of experiences of these succeeding years. You will read an argument by MacLaren, which seems to me perfectly valid today, on the care of selection of cases for cholecystectomy in which he points out that the general surgeon should not expect a less than 2 per cent mortality in the surgery of this field. I still believe that it is no disgrace to do a cholecystotomy. MacLaren cites several cases observed over several years with no return of symptoms. His opinion was that cholecystectomy was often performed because of a fear of a second operation. He had a belief that postoperative concern was in direct relation to liver injury, or exposure of the raw surface in the gallbladder bed. I tried to collect some evidence along this line, but the findings were so variable that no conclusions could be made. Yet over the years, I have been more concerned about direct injury to, traumatism of, and exposure of denuded surfaces, than I have been over the peritoneum. The peritoneum has a wonderful faculty of recuperation. What happens to the liver?

CONCLUSION

The following arguments can be listed in support of this plan, or similar plans:

1. Speed of achievement.
2. The assurance to the surgeon of an ineffable satisfaction in the knowledge that no damage has been done to structures outside the field. The plan of excision erases the possibility of injury to the liver and the danger of secondary hemorrhage.
3. It meets the first principle of any plan for cholecystectomy, the removal of the mucous membrane.
4. It provides drainage of the biliary system for cases of suspected pancreatitis.
5. It leaves a valuable guide to essential structures should a second attack on this field be indicated.

What I offer is an odd operation based entirely on clinical experience, which has developed into a formal series of steps to meet the requirements of the complicated situations.

I had hoped to have an impressive series of cases to report, but I have found but sixteen done by my associate, L. E. Daugherty, together with, or by, myself. The mortality has been nil. In but one case was there complication. I shall conclude my paper by an abstract of this case, which will give the picture of conditions under discussion:

CASE REPORT.—B. H., seventy-two years old, entered St. Luke's Hospital, St. Paul, Minn., June 14, 1933. *Previous illnesses:* Typhoid fever thirty years ago, suppurative appendicitis twenty years ago, and a severe attack of facial erysipelas one year ago—all intensely infectious diseases.

Present Complaint.—Progressive painless jaundice of three weeks' duration.

Recent History.—Has not felt well since April, 1933. Thought he had a cold and has felt weak and listless. Appetite fair—favorite foods, cabbage and fatty foods, weight loss of 15 pounds. For three weeks noticed white stools, dark urine, and itchy skin. No sharp colicky pains.

Examination.—Temperature and pulse normal, intense jaundice, achylous stools, and urinary findings of complete biliary obstruction. A palpable mass was found in the right upper quadrant of abdomen.

Preoperative Diagnosis.—(1) Carcinoma head of pancreas. (2) Gallbladder disease.

Operation.—After the usual examination and preparation for operation, the abdomen was opened to find a tense gallbladder completely hidden in adhesions which were easily separated, except at one point where time was taken to disprove perforation into the duodenum. There were stones in the gallbladder; cystic and common ducts were palpated. The gallbladder was split and many stones were removed. Several stones in the common duct were expressed through a dilated cystic duct, except one which was the site of such inflammation that the tissues of the common duct would not withhold retaining stitches. This stone was removed by sense of touch, and margins of the incision were promptly lost. An attempt to place a T-tube failed after many efforts. The gallbladder was removed by the plan above described; the cup and drainage were established. That night he suffered from acute urinary retention requiring catheterization. During the next week, more attention was given to the urinary bladder than to the wound, which drained bile through the tube in profusion. On the seventh day, the patient had a chill, high temperature, and acute delirium, and that evening the wound ruptured, requiring the usual midnight re-suture. This occurrence should be noted as it followed this particular technic. The patient recovered promptly from the second operation, bile was obtained in profusion, but there was no appearance of bile in the stools. He was discharged, to be taken care of at home. There was no bile in the stools which could not be explained by the ingestion of bile in the food.

In October, 1933, no positive improvement in local condition indicated further attack. The third operation was done at St. Luke's Hospital on October 4, 1933. The abdomen was opened to find that the handle of the ladle was a perfect guide to the common duct, which was promptly identified to find a stone which had receded into the liver sinuses at the first operation. This was removed, and a T-tube readily inserted. It was a great concern to note that there was still a debatable quantity of normal bile in the stools even after what seemed to be a careful exploration of the ducts. Gradually I came to the fear that all the manipulation of it had resulted in a constriction. This period of uncertainty was one of the most wonderful exhibitions of personal interest and professional care of this patient by his physician, E. V. Goltz. In about two months the situation began to clear up and the man, recently checked up, is apparently in splendid health.

EDEMA IN SURGICAL PATIENTS

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(From the Department of Surgery, University of Kansas School of Medicine)

THE development of edema in surgical patients is not an uncommon occurrence, particularly since the parenteral administration of liquid has become common practice. Patients depleted by starvation, infection, and blood loss may develop edema rapidly and to extreme degree if the quantity of parenteral liquid is excessive.

According to Starling's hypothesis,¹ edema is explained by variation in exchange of water between the blood and tissues, as determined by a balance between the hydrostatic pressure in the capillaries and osmotic pressure of plasma proteins. Lack of oxygen has been shown by experiment to increase the permeability of the capillary walls, permitting filtration of fluid and protein from the capillaries into the tissues.² Leiter³ was the first to attempt alteration of the osmotic pressure by depleting the plasma proteins by plasmapheresis. Since then, many variations of these experiments have developed, and a definite relationship between plasma protein depletion and the development of edema has been established. Jones and Eaton,⁴ in an excellent study, have applied this principle to surgical patients. They have referred to this edema as nutritional, since they feel that undernutrition is the principal factor in the pathogenesis of protein depletion. As contributing factors, they have mentioned blood loss, purulent drainage, and the general effects of sepsis. Jones, Eaton, and White⁵ observed in experimental animals that edema accumulates in the parenchymatous organs, as well as the subcutaneous tissues and draw the very reasonable conclusion that the cardiorespiratory apparatus will not function normally with an excessive quantity of water in the muscles of the heart and tissues of the lungs. Weech, et al.,⁶ in extensive experiments on dogs rendered edematous by inadequate protein intake and plasmapheresis, found that edema was not produced in the absence of salt intake. Other experiments indicate that the sodium ion is the edema producing element rather than chloride, since sodium bicarbonate produces edema, and potassium chloride results in weight loss and decrease of edema.⁷

The relationship of total serum protein depletion in the blood and the development of edema depends almost entirely on the depletion of the serum albumin content of the blood plasma. Bruckman and

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solutions used were 5 per cent dextrose alone, or in physiologic sodium chloride solution, or Ringer's solution. These solutions were at times modified to suit the body sodium chloride requirement.

If one studies all twenty-eight cases from the standpoint of total protein levels and the occurrence of edema, it is quite apparent that edema is closely associated with diminished total protein. Practically all of the cases presenting clinical edema had a total protein content of the blood of 5.5 gm. or less. However, several cases with a lower reading had no edema. Since the quantity of fluid intake influences the occurrences of edema, the total protein readings have been graphed with relation to the amount of fluid intake (Fig. 1). As can be seen in the chart, edema occurred in patients receiving 1,500 to 2,000 c.c. of solution daily. This may be explained in part by the fact that five of the

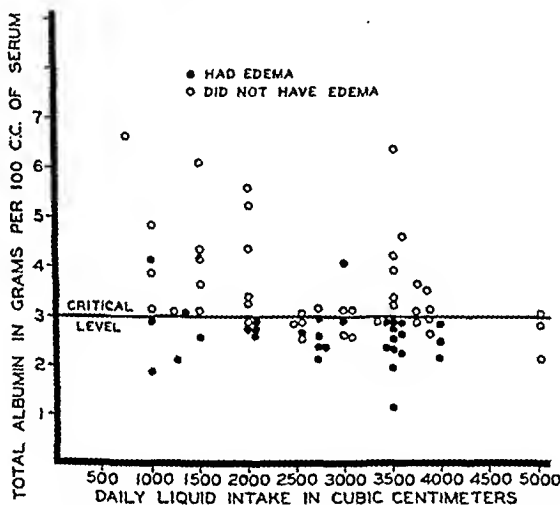


Fig. 2.—Seventy-four serum albumin determinations in twenty-eight patients.

patients were under sixteen years of age and received less total fluid, but as much or more in proportion to body weight than the adults. In several adult cases, receiving 3,500 c.c. or more of saline solution, edema was present when the total protein level was six gm. or more. The "critical level" of the serum albumin in this series is approximately 3 gm. per 100 c.c. of blood (Fig. 2).

In this study it was noted that those patients having gastric lesions or peritonitis were more likely to show a decrease in protein and to develop edema.

It is quite apparent that there is a close parallel between the decrease in total protein and the albumin fraction. The globulin is independent of this decrease and often increases, producing an inversion of the albumin-globulin ratio.

In an analysis of the cases from a standpoint of edema and prognosis, it can safely be said that only those cases seriously ill develop

Peters⁸ indicate that edema almost invariably develops when the serum albumin falls below 3 per cent in patients with malnutrition. It is their opinion that osmotic pressure is influenced far more by albumin than by globulin. Moore and Van Slyke⁹ conclude that the tendency to edema in nephritis, except in rare cases, appears to be correlated about as closely to the total protein as to the albumin fraction. They estimate that edema is usually present with a total protein of 5.5 ± 0.3 per cent, or albumin 2.5 ± 0.2 per cent. The point in the reduction of total protein or serum albumin at which edema appears has been termed the "critical level."

A series of twenty-eight surgical cases has been studied in the University of Kansas Hospitals in an effort to determine the type of sur-

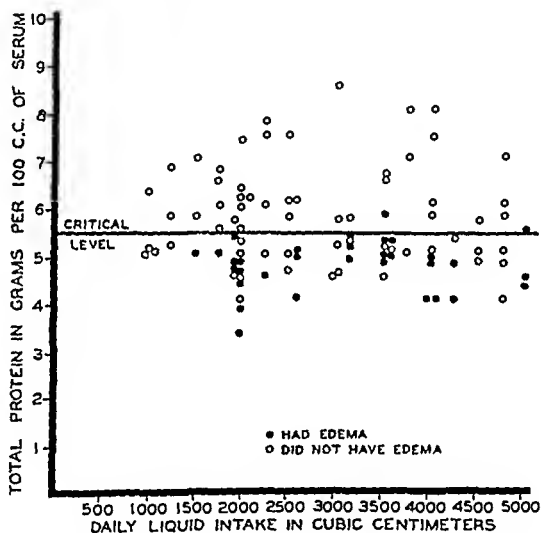


Fig. 1.—Ninety-seven total serum protein determinations in twenty-eight patients.

gical patients most likely to develop protein depletion and edema, the effect of low serum protein and edema on prognosis, and the most effective method of combating such changes. In this series are included eight cases of appendicitis with peritonitis, four cases of appendiceal abscess, two cases of perforated peptic ulcer, three cases of intestinal obstruction, four cases of carcinoma of the stomach, and one case each of Banti's disease, hypernephroma, simple acute appendicitis, second degree burns, Piek's disease, pyloric obstruction, and hypertrophied prostate. These cases were selected, either because they presented evidence of edema, or because there was reason to expect protein depletion because of impaired nutrition. The group of gastric malignancies and peritonitis cases were treated by gastric suction and thus subjected to starvation. Repeated blood protein determinations were made and fluid intake and output recorded. The

solutions used were 5 per cent dextrose alone, or in physiologic sodium chloride solution, or Ringer's solution. These solutions were at times modified to suit the body sodium chloride requirement.

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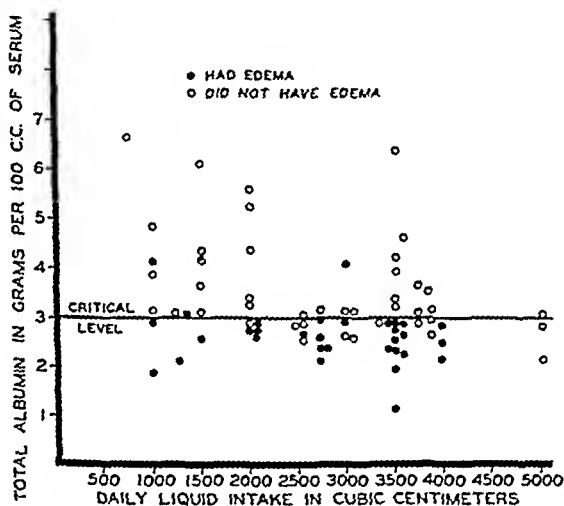


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TABLE I

BRIEF CASE REPORTS OF THREE PATIENTS WITH PERFORATION OF THE APPENDIX AND PERITONITIS. EARLY APPENDECTOMY WITH DRAINAGE. RECOVERY. EDEMA DISAPPEARED IN ALL CASES IN THREE TO FIVE DAYS AFTER DISCONTINUING SODIUM CHLORIDE INTAKE AND STARTING FOOD BY MOUTH

SEX AND AGE	POST-OPERATIVE DAYS	TOTAL SERUM PROTEIN, GM. PER 100 C.C.	SERUM ALBU- MIN, GM. PER 100 C.C.	SERUM GLOBU- LIN, GM. PER 100 C.C.	NONPROTEIN NITROGEN, MG. PER 100 C.C.	WHOLE BLOOD CHLORIDES, MG. PER 100 C.C.	PROGRESS NOTES
Male, 69	6	5.04	2.87	2.17	37	470	Edema appeared on eighth postoperative day. Average daily intake of Ring-er's solution, 2,000 c.c. Transfusion of 500 c.c. of blood on twelfth postoperative day.
	9	5.08	2.69	2.39	40	500	
	12	4.08	2.59	1.51	32	410	
	16	6.29	3.09	3.20	31	450	
Male, 23	0	5.83	3.96	1.87	34	450	Edema appeared on sixth postoperative day. Average daily intake of Ring-er's solution, 3,250 c.c. Transfusion of 400 c.c. of blood on seventh postoperative day, and 500 c.c. on twelfth postoperative day.
	4	5.26	2.98	2.28	30	470	
	8	5.23	2.37	2.86	29	480	
	19	5.01	1.03	3.98	29		
Male, 12		5.45	2.77	2.68			Edema appeared on fifth postoperative day. Average daily intake of Ring-er's solution, 2,000 c.c. (weight of patient 99 pounds). Blood trans- fusion of average 375 c.c. on seventh, ninth, thirteenth, and four- teenth postoperative days. Began protein feeding on eleventh postop- erative day.
	5	5.44	2.71	2.73	25	400	
	7	4.95	2.86	2.09			
	10	4.95	2.51	2.44	27	450	
	11	5.68	2.81	2.82	35	450	
	16	4.47	2.09	2.38	24	445	
	22	7.56	3.06	4.50			

edema. Of the twenty-eight cases, fourteen presented clinical edema, and, of these fourteen cases, five died. Included in the list of five deaths are one case of Pick's disease, one of Banti's disease, one of carcinoma of the stomach, and two with perforated appendix and peritonitis. It is doubtful if the first three deaths were influenced in any way by edema. It is possible that edema might have been a lethal factor in the two cases of peritonitis. One of these patients had pulmonary edema. While it is impossible to state with certainty that the development of edema influenced the death rate in this series, we can say with assurance that all patients having edema were seriously ill.

In each of those cases developing edema, particularly the peritonitis cases, an effort was made to replenish the blood proteins by blood transfusion and, in this way, relieve the edema. A transfusion of 500 c.c. of blood has little effect on the total protein content of the blood serum. A single transfusion cannot be expected to raise a depleted blood protein of the recipient a great deal, since the donor's blood contains only the normal quantity of total protein which is greatly diluted by the recipient's blood. However, repeated transfusions are beneficial and usually effect a gradual rise in blood proteins. It is impossible to say from our data whether blood transfusions have a desired effect on the edema, since the intake of water and sodium chloride was reduced as soon as edema appeared. In several instances, it was noted that the urinary output was increased following such measures.

SUMMARY

Returning to our original three questions in summary, it can safely be stated, from the study of these cases, that the patient most likely to develop surgical edema is one subjected to starvation associated with an infection such as peritonitis. Edema need not be expected if the total serum protein is not permitted to fall below the critical level, and if the intake of sodium chloride is not excessive. Edema appeared only in those cases of prolonged and serious illness, and for this reason the occurrence of edema in any surgical patient is one of the many signs suggesting the seriousness of the illness and a possibly unfavorable outcome. When the development of this complication occurs or is imminent, as shown by blood protein depletion, repeated transfusions are indicated. If edema develops, the intake of sodium chloride should be immediately discontinued. A 5 per cent dextrose solution may be given to supply the necessary liquid.

CONCLUSIONS

Because of the danger of edema, parenteral feeding and watering should be discontinued as early as possible. The sick surgical patient should have food and water by mouth as soon as they can be tolerated.

Metabolic balancee cannot be maintained by giving dextrose, sodium chloride, and water by parenteral methods. With a low serum protein, sodium chloride is the principal edema producing factor when administered in excessive quantities.

In this series of twenty-eight patients, those having gastrointestinal disease, to whom food could not be given by mouth for several days, showed the greatest tendency to develop edema.

While evidence that patients with low serum protein and edema are favorably influenced by transfusions is not conclusive from our observations, we believe that repeated transfusions are indicated when protein cannot be immediately given by mouth.

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DIVERTICULOSIS OF THE SMALL INTESTINE: REPORT OF THREE CASES

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TWO varieties of diverticula occur in the intestinal tract, the acquired and the congenital. When all the layers of the normal intestinal wall are present in the diverticulum, it is called a true one. The familiar Meckel's diverticulum is a true congenital diverticulum. The acquired variety are of the mucous membrane hernia type and have little or no muscular fibers in their walls. This type of false diverticula may occur in any portion of the gastrointestinal tract, but it is most frequently found in the sigmoid and duodenum. This paper concerns the infrequent, acquired diverticula that occur in the small intestine.

Historical.—The literature of multiple jejunal diverticula begins with Sir Astley Cooper's description, in 1844, of numerous pouches in the upper jejunum of a sixty-five-year-old man. Sir William Osler, in 1881, recorded the case of a sixty-five-year-old male with fifty-five upper jejunal diverticula, varying in size from that of a cherry to that of a large apple. Virchow, Edel, Grassberger, Henseln, Hansemann, Hanau, and Nicholls each described cases before 1900. Klebs, Hansemann, and Hanau devoted their attention to the subject in 1896. Klebs first suggested the opinion now generally held that the pressure of fluid and gas in the intestine is the initiating force of the diverticula. Hanau produced trenchlike furrows on the mesenteric border of a loop of bowel filled with water and subjected to hydraulic pressure. In this way Hansemann produced in the intestines of old persons diverticula related to the blood vessels. Chlumsky found that the intestines of living dogs ruptured on the antimesenteric border, but that on distending intestine removed from a dog, ten hours after death, they ruptured into the mesentery. It was Klebs who first noted the relationship between the diverticula and the blood vessels; he described the site of entrance of the blood vessel through the intestinal wall as the *locus minoris resistentiae*. His belief that the blood vessels caused a drag upon the mucous membrane has not been substantiated.

Graser, in 1899, thought venous congestion was a factor in causing a weakened area in the bowel wall. In 1900, Sudsuki suggested that the degeneration of the connective tissue sheath of the veins produced a site of lowered resistance. Fischer, in 1900, held that chronic constipation, traction, chronic passive congestion, and gas pressure were of etiologic significance. He found that the circular muscle first disappeared with the outer coat remaining intact for some time. After the diverticula attained a large size, the outer muscular coat also disap-

peared; once the herniation had started through the gap produced by the blood vessel, it then followed the line of least resistance, which was not always along the blood vessel. Beer reviewed the subject in 1904. Gordinier and Sampson described a case, diagnosed at operation, in 1906. The roentgen diagnosis of the condition was first described by Case, in 1920, who reported the first case so diagnosed.

By 1924, Watson found that twenty-nine cases of jejunal diverticula had been recorded; in 1935, Rosedale found seventy-one recorded cases. As yet, less than 100 cases have been reported. Recent reviews of the subject have been written by Chapman, Edwards, Schmidt and Guttman, and by Rankin and Martin.

Incidence.—Case found an incidence of 1 in 1,000 (0.1 per cent) in 10,000 consecutive barium meal examinations, as compared with 1 in 200 (0.5 per cent) postmortem examinations done at Johns Hopkins Hospital. Rankin and Martin reported that 1 case to 36,357 barium examinations of the stomach and duodenum were found at the Mayo Clinic; however, 3 cases were found at the Mayo Clinic in 957 stasis examinations of the small intestine. Larimore and Graham found 3 cases in 3,446 complete gastrointestinal studies. Rosedale found 3 cases in 5,000 autopsies. Edwards found 5 cases in 881 autopsies during the past four years when particular search for the condition was made, an incidence of 0.57 per cent which he feels is quite accurate. From these statistics, it is evident that many cases will not be found by the pathologist or roentgenologist who does not examine the small intestine with the condition in mind.

Age and Sex.—Chapman found in his review that 13 were males, averaging 62.8 years of age, and 8 were females with an average age of 59.7 years. In Rankin and Martin's 52 cases from the Mayo Clinic, there were 38 males; the average age of the group was 55.6 years, and the ages varied from 21 years to 82 years. The diagnosis was made at operation in two cases, and in each case the patient was 65 years of age. The average age of the 11 cases reported by Edwards was 56 years; 8 of his patients were males.

Pathology.—For a detailed description of the condition, the reader is referred to the recent article by Edwards, who has summarized his findings as follows: The diverticula may be either single or multiple, the site of herniation corresponding with the site of entry of the blood vessel; thus the diverticula are typically located on the mesenteric border. In case of a diverticulum on the antimesenteric border, the opening corresponds with the entrance of an unusual vessel. During their formation, the diverticula carry with them a layer of muscle which is absent in the fundus of the large diverticula.

Fig. 1 is a photograph of a portion of the specimen removed from the first case seen in the Guthrie Clinic. This site shows the variations in the size of the diverticula and also shows their situation in regard to the mesenteric line. It is noted that all the diverticula shown, with

the exception of one very large one on the extreme right, arise on one side or another of the mesenteric line. At no place was there symmetrical herniation on each side of the mesenteric line. The medium-sized bilobed diverticula were formed by two diverticula on the same side of the mesenteric line, becoming continuous. Only rarely did the fusion occur across the mesenteric line, and then only when the diverticulum was of exceptional size.

The relation of the blood vessel to the diverticula is shown in Figs. 2 and 2A. This also shows the extreme variation in the size of the diverticula that may be present in one segment of the bowel. The small diverticula have only one vessel related to them. After fusion of two or more diverticula has taken place, there are two or more vessels related to the ultimately formed diverticulum.

The large diverticula are very thin and transmit light readily. Their walls contain only mucous membrane and serosa. In the small diver-

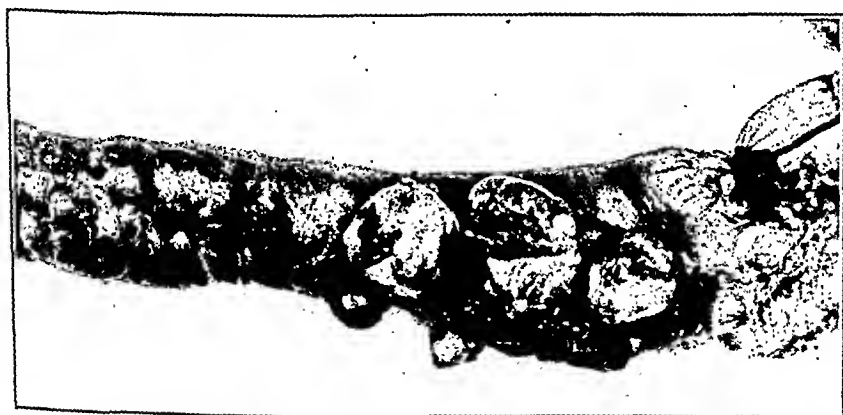


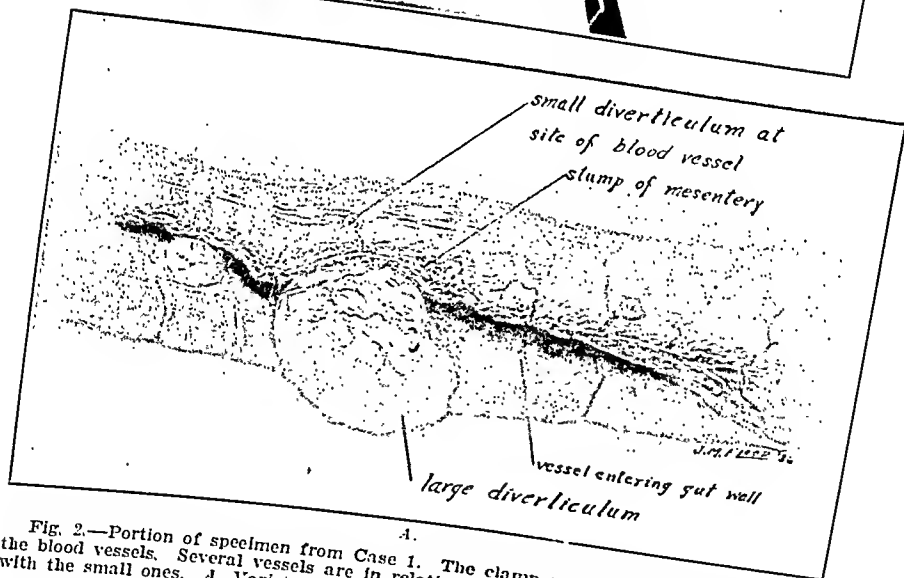
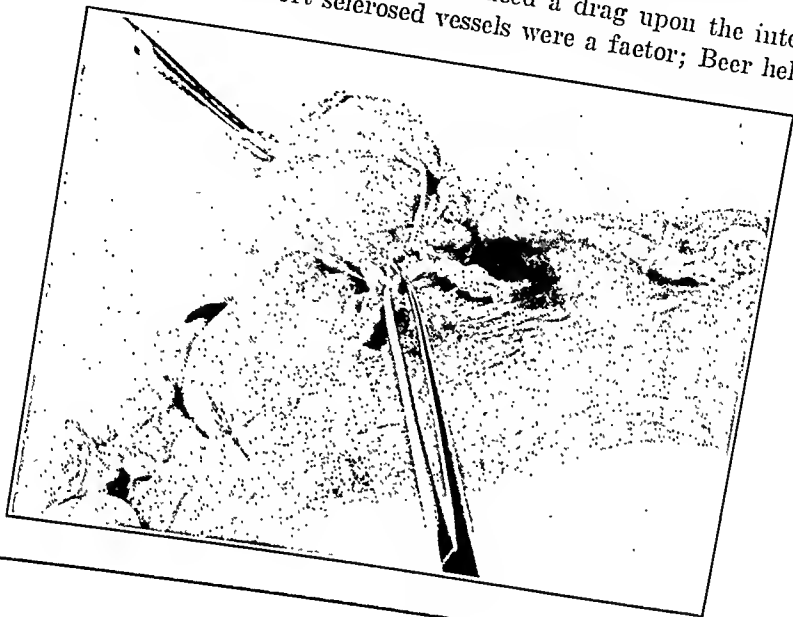
Fig. 1.—Portion of small intestines removed from Case 1. All sizes of diverticula are present. The relation to the blood vessels is shown in several places. The point of origin on either side of the mesenteric line is clearly shown near the midportion. The medium-sized diverticulum on the left is of the bilobed type. On the extreme right is one of the few diverticula in the whole specimen removed that extends across the mesenteric line and thus was formed by fusion of two smaller diverticula, originally on both sides of the mesenteric line. Note the increased diameter of the bowel in the region of the larger diverticula.

ticula, the wall is found to increase in thickness since there has been less stretching of the wall. Muscle fibers are present in the smaller diverticula. The diameter of the bowel is increased where many diverticula are present close together.

Figs. 3 and 4 are photographs of the specimen from the third case seen at the Guthrie Clinic. The specimen was resected at operation, and the ligatures on the mesentery are not to be confused with the diverticula. The condition is not as far advanced as in the first specimen, but otherwise differs in no essential from it.

Pathogenesis.—Edwards states that there is no doubt that the type of diverticula under discussion are acquired deformities. Their pathologic anatomy is to be explained only by the thesis that the pouches are hernias of the mucous membrane through the muscular wall of the

intestine. Since the origin of the diverticula corresponds exactly with the point of entry of the blood vessel through the muscular coat, it is generally agreed that this forms the *locus minoris resistentiae*, first mentioned by Klebs. Klebs believed that the vessels produced a drag upon the intestines; Helvestine thought short sclerosed vessels were a factor; Beer held that



A.

Fig. 2.—Portion of specimen from Case 1. The clamp and forceps are attached to the blood vessels. Several vessels are in relation with the large diverticula, only one with the small ones. A, Variety of symptoms shown by above reported cases.

degeneration of the intestinal musculature was present: Braithwaite suggested a parasymphilitic origin; Sudsuki thought degeneration of the connective tissue sheath of the veins was present. A myogenic cause was advocated by several writers, such as Roth's fatty degeneration,

Buzzi's congenital hypoplasia, and Spriggs and Marxer's toxic myositis. Jordan and Lahey assume that the acquired type is due to congenital anatomic or pathologic weakness. Rankin and Martin believe that the



Fig. 3.—Specimen of small bowel removed from Case 3. The mesentery has not been dissected, and the ligatures placed at operation are in place and form the mesenteric line. The diverticula are seen extending to one side of this line, almost all of them on the same side. Without some dissection, the mesentery recognition of seven of the twenty-two diverticula is difficult.

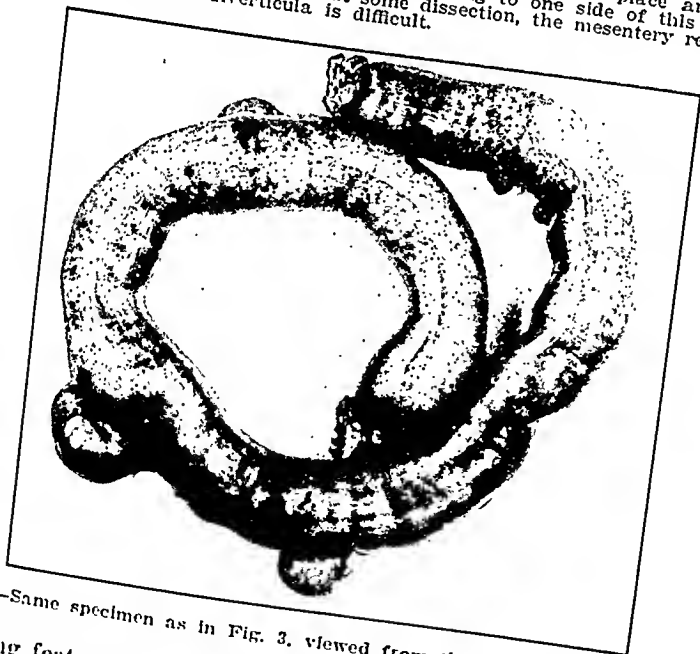


Fig. 4.—Same specimen as in Fig. 3, viewed from the antimesenteric border.

outstanding features are an inherent weakness of the wall of the bowel and an increased intraintestinal pressure; they believe that congenital weakness, obesity, venous stasis, and constipation are predisposing

factors. Chapman attempts to explain diverticula formation as a process analogous to aneurysmal formation: "changes in the connective tissue, loss of elastic tissue, something analogous to hyaline changes in the submucosa and finally hammer-like changes in pressure due to rapid contractions alternating with periods of complete emptiness." Edwards explains the increased intraintestinal pressure on the basis of irregular contractions of the musculature: "As the contents are prevented from passing along the bowel by the irregular contraction, the pressure in the relaxed portion is increased and the contents are being squeezed against the mucous coat and tend to push between any interval that can be found between the muscle fibers. The vascular channels, gaping to their fullest in the relaxed muscle wall, offer the mucous membrane loci minoris resistentiae." Barling described an early stage of diverticulosis of the colon that was observed at laparotomy: "The bowel suddenly narrowed at one point till it was no thicker than the index finger, it became extremely rigid and while the spasm lasted, tiny saccules appeared between the longitudinal bands, lying like beads along the sides of the gut. In a few seconds the spasm passed off and the tiny projections could no longer be seen."

Thus all are agreed that the two major factors are the point of decreased resistance at the site the blood vessel enters the bowel, and the increase in the intraintestinal pressure. Edwards' explanation is the most logical and is substantiated by laparotomy and roentgenologic observations. It is highly probable that the three patients here reported were sufferers from irregular intestinal contractions. The first patient developed a duodenal ileus and died on the sixth postoperative day. The high intestinal ileus may quite rightly be thought of as a very advanced degree of irregular contractions. The second patient developed a vicious cycle after a posterior gastroenterostomy which had been correctly done, as shown by the second operation. In the third case, an otherwise perfect convalescence was marred by a temporary high intestinal ileus. These findings in the three cases support the theory of Edwards that irregular intestinal contractions are an etiologic factor in the formation of diverticula, inasmuch as some form of functional derangement revealed itself in the upper intestinal tract associated with the presence of jejunal diverticula.

Symptomatology.—The two outstanding symptoms common to Edwards' four cases, in which a diagnosis of diverticula was made by means of roentgenography, were vague abdominal pains at an interval after meals and flatulence corresponding in time incident with the pain. That these symptoms can be definitely attributed to the presence of the diverticula is shown by the relief from these symptoms after the diverticula had been removed at operation. Rankin and Martin found that the majority of their cases gave no distinctive symptoms referable to the gastrointestinal tract. Tengwall states that vague digestive disturbances with occasional nausea are usually met with in diverticu-

losis, but that the commonest symptom is bleeding from the bowel. This is contrary to the experience of others. Braithwaite's patient vomited five pints of unaltered blood.

In five cases here reported, bleeding either from the bowel or hematemesis has been present as shown in the accompanying table. Hence the incidence of bleeding is around 6 per cent, including the case reported here.

CASE REPORTS

CASE 1.—A seventy-year-old, white male entered the Clinic May 18, 1929, complaining of loss of weight and strength for the preceding year. During the preceding



Fig. 5.—Case 1. Portion of jejunum (five feet) removed.

month, he had had a diarrhea that had started suddenly; previously, he had never had any bowel or stomach trouble of any kind. The stool contained considerable mucus, but no blood. His local physician had given him some medicine which he thought might be the cause of his expectoration of considerable material. During the few days prior to admission, he had vomited on several occasions. His past history was essentially negative. Physical examination showed a man weighing 155 pounds, who had recently lost considerable weight; his normal weight was 215 pounds. He had several bad teeth; his tonsils were enlarged; his blood pressure was 122 systolic and 80 diastolic. Examination of the chest and abdomen revealed no abnormalities. He had several large external hemorrhoids, and his prostate was moderately enlarged.

Further studies of the patient in the hospital revealed the following: red blood cells, 5,440,000; hemoglobin, 85 per cent; white blood cells, 8,200; differential,

77 per cent neutrophiles, 23 per cent small lymphocytes; blood sugar, 91 mg. per 100 c.c. of blood; blood urea, 46 mg. per 100 c.c. of blood; urine, negative; stomach contents, no free acid, combined acid, 19 to 31 units; stool, occult blood positive; gastrointestinal series, stomach riding high with considerable narrowing of the pylorus, no retention or evidence of ulcer. The temperature, pulse, and respiration were normal during the period of study.

A preoperative diagnosis of carcinoma of the stomach was made and operation advised. At operation on May 29, 1929, many (70) diverticula of varied sizes of the jejunum were found (Fig. 5). These began four inches from the ligament of Treitz and extended down the jejunum five feet. The first foot of the jejunum was bound down with peritoneal adhesions causing an acute angulation. This portion of the jejunum was twice normal size. The large intestine, stomach, duodenum, and gallbladder were negative. The involved portion of the jejunum was resected and an end-to-end anastomosis performed. The course following operation was stormy. The temperature remained normal; the pulse rate varied from 100 to 120. Frequent gastric lavage was necessary. The clinical picture was that of a high intestinal obstruction which was considered to be paralytic. The patient died on the sixth postoperative day. Postmortem examination was limited to the operative incision. The peritoneal cavity was free from infection. The end-to-end anastomosis was patent, and no point of obstruction could be discovered. The intestines were normally collapsed.

CASE 2.—The patient was a sixty-year-old male, father of a former Packer Hospital interne; a strong personal interest and an added sense of responsibility were thus present in the desire to relieve this man of his trouble. His first admission, which was of three days' duration, was December 28, 1934. His complaints were of abdominal pain after meals and at night relieved by soda and by vomiting. During the preceding two months, this had become progressively worse. Hematemesis and melena were absent. Physical examination was essentially negative. Laboratory studies revealed the following: red cells, 4,040,000; white cells, 7,200; 57 per cent neutrophiles, 43 per cent lymphocytes; urine contained 3.5 per cent sugar; blood sugar, 210 mg. per 100 c.c. of blood; blood urea, 31 mg. per 100 c.c. of blood. Free hydrochloric acid of the stomach ranged from 26 to 80 points, total acid ranged from 50 to 96 points. Roentgenographically the stomach was slightly up and over to the right. There was a small amount of ragged narrowing of the pyloric ring extending into the base of the cap; this was easily smoothed out. Peristalsis was slightly exaggerated and motility was good. That portion of the jejunum which lies immediately under the pyloric end had a strong suggestive appearance of a diverticulum which might be due to adhesions (Fig. 6). We were suspicious of pathology at the pyloric end of the stomach. No retention at five hours.

A diagnosis of peptic ulcer, or possible malignancy, and of diabetes mellitus was made. Before leaving the hospital he was given a diabetic diet and a prescription for belladonna and alkaline powders. Operation was advised.

The patient returned to the hospital on January 5, 1935. He was prepared and operated upon January 9, 1935. At operation a chronic duodenal ulcer was found. Considerable difficulty was experienced in locating the first part of the jejunum. During the early part of the operation, the patient stopped breathing several times. Gastroenterostomy was decided upon; no diverticulum was found in the loop of jejunum anastomosed to the stomach and in the relief of the anxiety over not finding a malignant lesion, exploration was not carried further. Two weeks after operation, the patient began vomiting, associated with epigastric distress. Roentgenographic examination with a small amount of barium revealed slightly exaggerated peristalsis, the stomach emptying more through the duodenum than through the stoma, and an apparent rubber hose kinking of the jejunum distal to the anastomosis. This appeared to regurge, completing the vicious cycle. At the

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that were very thin and translucent, showing that they had formed from the coalescence of smaller diverticula and were the type of acquired, mesenteric, pulsion diverticula under discussion. Following operation, the general condition of the patient gradually improved, and he was discharged after four weeks.

CASE 3.—A white male, fifty-four years old, entered the hospital February 8, 1936, because of several large hemorrhages from the bowel. During the preceding year, he had occasionally experienced attacks of mucous diarrhea that he attributed



Fig. 7.—Case 3. Roentgenogram taken five hours after barium meal, showing retention of barium in several diverticula.

to dietary indiscretions. Six weeks previous to admission, the diarrhea recurred. At this time, the stool contained large quantities of mucus and occasionally some blood. Quite regularly he awoke at 4:00 A.M. and passed a loose stool without discomfort. He had not lost weight or strength. The patient was very apprehensive on admission, his skin was moist, and he was slightly pale. His blood pressure was 170 systolic and 100 diastolic, and there was systolic murmur over the precordium. Abdominal examination was negative to palpation. The rectum contained a mass of old blood. Laboratory examinations revealed: red cells, 3,700,000; white

end of one hour, there was very poor motility of the small intestine; at three hours, there was 50 to 60 per cent retention in the stomach; and at six and one-half hours, there was 30 per cent retention.

A second operation was performed three weeks after the first operation. In the middle of the proximal loop of the jejunum, a large diverticulum was present; a second was present 12 inches below; and a third 20 inches below. Each was thin walled and on the mesenteric border. The presence of the ulcer was verified and the gastroenterostomy stoma was patent. The first and second diverticula were dissected free down to the base, the base crushed and ligated, a purse string of catgut run around the base, diverticula removed, and the stump treated with merthiolate



Fig. 6.—Case 2. Roentgenogram showing a large diverticulum of the jejunum.

and inverted. The outer coats of the bowel were closed over the stump with interrupted chronic catgut sutures; the rest in the mesentery was closed. The third diverticulum was small and was not removed. Because of the reported obstructive point from which the food or bismuth was regurgitated back into the stomach, it was decided to do an enteroenterostomy. Since the cause of the regurgitation was not mechanical, and in view of the poor intestinal motility with regurgitation into the stomach as shown by fluoroscopy, the cause of the vicious cycle may quite likely have been a functional derangement of muscular coordination corresponding to the irregular contractions described by Edwards.

The diverticula removed were approximately the size of an English walnut, one larger and one smaller. The walls of both contained many small bulging sacculae

and involving the next twenty-three inches (Figs. 3, 4, and 8). Four of the diverticula were large, and seven were medium sized. The involved portion was resected and an end-to-end anastomosis done with the Rankin clamp. The convalescence was smooth until the tenth day; at this time, daily gastric lavages became necessary for four days. A flat plate of the abdomen taken on the fourteenth day showed distention of the stomach and duodenum. The obstruction to the lumen was thought to be due to a plugging of anastomosis or to a duodenal ileus. Following the administration of castor oil, the condition righted itself. The patient was discharged from the hospital on March 22, 1936. He was seen again on May 22, 1936, and had gained twenty pounds in weight, was working hard, and felt better than at any time during the preceding year. He reported by letter, dated July 10, that he was well.

The common findings of these three cases were: the sex, all were males; the age, fifty-four years of age or older; and the type of diverticula found. The first patient had the most advanced pathology and was the oldest; his age was seventy years; he had seventy diverticula in 60 inches of small bowel. A duodenal ulcer and diabetes mellitus were coexistent in the second case. The third was one of these rare cases where a diagnosis could be made by roentgen examination, and thus a diagnosis was made before operation. This case was also rare in that profuse rectal bleeding was the chief complaint. Further, the operation was the ideal procedure of resection and anastomosis, and the patient is now in perfect health. Two of these patients had a mucous diarrhea before admission, and all three had some derangement of the function of the upper intestinal tract after operation. We are inclined to the belief that this latter manifestation is in favor of the theory of Edwards that irregular intestinal contractions play a part in the etiology of the formation of diverticula.

Complications.—The complications of diverticulosis are diverticulitis, hemorrhage, perforation, intestinal obstruction, and enterolith formation. The development of these conditions may be as follows: Infected material enters the diverticulum from the bowel where it becomes shut off. The prolonged contact with the mucous membrane which has its blood supply impaired due to the ballooning, favors the development of an inflammatory process. This process may erode a vessel, resulting in hemorrhage. The hemorrhage may also result from tearing of a blood vessel when the diverticula become excessively distended. The inflammatory process may involve the serosa which then becomes sealed to the surrounding structures and causes a partial or an acute intestinal obstruction; or the process may rapidly erode through the wall, perforate, and cause a general peritonitis. The material that enters the diverticula may become hardened and form an enterolith.

Diagnosis.—A diagnosis from clinical examination alone has not been done. A diagnosis preoperatively is possible when the diverticula fill partially or completely with barium, presenting a ball of barium as

cells, 7,200; neutrophils, 65 per cent; lymphocytes, 35 per cent; urine, negative; Kahn, negative; blood urea, 38 mg., and blood sugar, 75 mg. per 100 c.c. of blood; platelets, 200,000; coagulation time, 6 minutes; bleeding time, 30 seconds. A whole blood transfusion was given February 10, 1936.

The intestinal tract was cleaned out very slowly, using mineral oil and mild laxatives. For this reason, several proctoscopic examinations were not satisfactory because of the old blood. After the blood was all removed, no abnormalities were found by proctoscopic examination. Two barium enemas were given; these revealed spasticity of the rectal pouch and some narrowing of the sigmoid. Two areas were

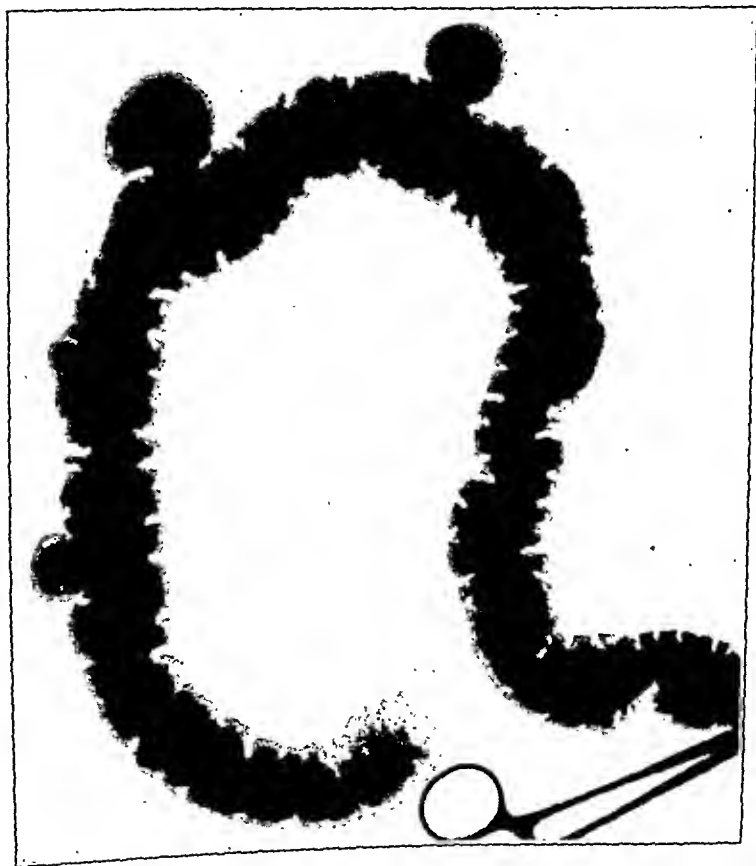


Fig. 8.—Case 3. Roentgenogram of barium-filled portion of jejunum removed at operation.

suggestive of diverticula. The terminal ileum showed some gaseous distention. Air injection was done, but no gross pathology could be demonstrated. After a thorough cleansing of the intestinal tract, a delayed barium meal examination was made. The stomach and duodenum were normal. After five hours, the stomach was empty, and the meal was distributed throughout the terminal ileum. A few small dilated portions of the small bowel had retained the barium. These were interpreted as diverticula of the small bowel (Fig. 7).

At operation on February 20, 1936, twenty-two varying sized mesenteric diverticula of the jejunum were found, beginning four inches from the jejunojejunal junction

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described by Case. The diagnosis in Case 3 was made upon the film shown in Fig. 7. The barium balls are evident. Most cases are discovered at operation or diagnosed at postmortem examination.

Treatment.—The treatment is surgical. The process begins in the sixth decade and is gradually progressive. The only possible means of relieving symptoms caused by diverticula is the removal of the diverticula. Resection of the involved portion of bowel is the ideal procedure. The extent of the process or the location of the diverticula may necessitate a less radical procedure. Simple excision of the diverticula or a sidetracking operation may be done.

SUMMARY

Approximately 100 cases of diverticulosis of the small bowel are on record. The condition may be diagnosed by roentgen examination or discovered at operation, but the presence of diverticula is most often established at autopsy.

Three cases are reported. The diagnosis was made at operation in two, and by barium meal in one. The latter case was confirmed at operation, the involved portion was resected, and the patient is now in excellent health. The first patient died following resection of five feet of small bowel. The second patient recovered after excision of the diverticula and an enteroenterostomy. (He had a gastroenterostomy three weeks previously for a duodenal ulcer.)

A frequent clinical picture is vague abdominal pain associated with flatulence. Based on very careful studies, the incidence is approximately 0.5 per cent (1 in 200 patients).

The two important factors in the pathogenesis are a point of lower resistance where the blood vessel enters the intestine, and an increase in the intraintestinal pressure. The development of the latter is explained on the basis of irregular intestinal contractions. According to this theory, a portion of the bowel relaxes while the segments on either side are contracting. These contractions force the mucous membrane into the gap where the blood vessel enters in the relaxed segment.

Acquired diverticula of the small bowel are usually multiple, occur on the mesenteric border, and arise in the upper portion of the jejunum.

The treatment is surgical, preferably resection of the bowel, but simple excision of the diverticula or a sidetracking operation may suit the case better.

The condition is probably one of the most frequent causes of vague abdominal complaints.

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In most of these methods, the object is to avoid the necessity of cervical dilatation, which is a painful procedure usually requiring at least light anesthesia.

In other cases, where only a single histologic study is required, there is usually no objection, and there may be much advantage, in making the curettage a thorough one, especially as a more comprehensive picture of the endometrial histology is thus obtained. This is likewise true if the indication for the curettage is either partly or entirely a therapeutic one. Even greater is the need for thoroughness in curettage in the diagnosis of suspected pathologic lesions, for an incomplete curettage may, for example, miss an area of early adenocarcinoma.

In a very large proportion of cases of this group, the curettage can be performed without dilatation and without anesthesia, by means of the suction curette which I recently described, and I believe better by this instrument than by any of the several other appliances which have been devised for this purpose. The suction curette which I employ is, as seen in Fig. 1, simply a long cannula, with a uterine curve, and with

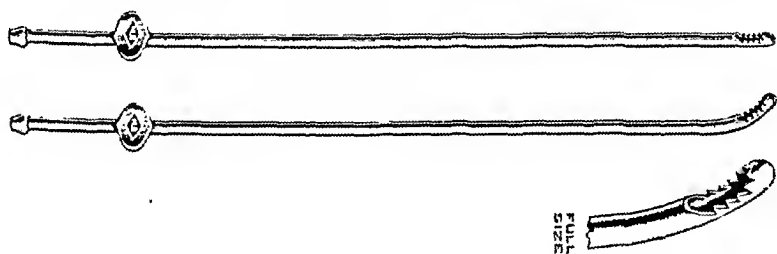


FIG. 1.

a sharply serrated cutting upper edge to the fenestrum, which is on the concavity of the curve near the open extremity. The cannula is about the diameter of the ordinary Rubin cannula for tubal insufflation, so that it easily slips into most cervixes without previous dilatation. I need not go into the details of antiseptic cleanliness, which are clearly important. The proximal end of the cannula is attached by a very stiff tubing, sufficient to resist collapse from fairly strong negative pressure, to the bottle for collection of the curettings. This bottle, in turn, is connected with the suction apparatus, which can be either the simple water pump or the electric motor suction so generally used in operating rooms.

The suction is really a valuable adjunct to the curettage, for loose particles of perhaps scanty curettings are thus not lost in the uterine cavity, being drawn into the bottle, or at least into the tubing. From the latter they will readily pass into the bottle, if, at the completion of the curettage but with the suction still on, the end of the curette is dipped for a few moments into sterile saline solution. This solution is better for this purpose than formalin, which may cake the particles

THE DIAGNOSTIC AND THERAPEUTIC APPLICATIONS OF THE UTERINE SUCTION CURETTE

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ONE of the most frequently useful of all gynecologic instruments, in my opinion, is the uterine suction curette. I do not believe its possibilities are fully appreciated by the general profession. The old days of promiscuous curettage for all sorts of indications, including such conditions as amenorrhea, sterility, and leucorrhea, are about over, and there is now a sharp restriction in the indications for this not always simple and safe little operation. Yet there are still a very large number of cases in which the procedure is clearly advisable. In the diagnosis of the cause of uterine bleeding, for example, the curette, together with the microscope, yields information which can be obtained in no other way, and which may actually be of life and death value to the patient.

In these days of intense interest in gynecologic endocrine disorders, moreover, a great new field has been opened in which a knowledge of endometrial histology is of the greatest clinical value. It should be remembered that the endometrium is under the physiologic subservience of the ovarian hormones, and, beyond them, of the dominating gonadotropic hormones of the anterior hypophyseal lobe. This is not the place to review the effects of these hormones upon the uterine mucous membrane, but they are quite distinctive, and, to a large extent at any rate, associated with characteristic histologic changes. The endometrium is therefore a very reliable mirror of these endocrine activities, and I believe it is possible, in the present state of blood and urine hormone studies, to obtain more information as to the nature of gynecologic endocrine disorders from histologic study of the endometrium than from studies of the hormone content of the blood and urine.

In many of these cases, complete curettage is unnecessary and undesirable, especially where the histologic study must be repeated at rather frequent intervals, to determine the occurrence or nonoccurrence of cyclical histologic changes. A variety of simple ambulatory procedures have been devised for this purpose, based on one form or another of punch biopsy, aspiration, or curettage with a very small instrument.

considerable number of gynecologists throughout the country. The method is not employed in the treatment of incomplete abortion, as the tissue masses often present in such cases would not pass through the cannula. It is in this group, in which the uterine wall is so often soft and unresisting, that the largest incidence of perforations is noted. Certainly, however, suction curettage should not be persisted in if there is any difficulty in introducing the cannula. Were perforations to occur with the suction curette, it is quite possible that the resulting damage to the intestine or other viscera might be much more serious than with the ordinary curette, because of the suction element. In the hands of the experienced gynecologist, however, it may be fairly said that the procedure is, in properly selected cases, almost devoid of danger.

What, then, are some of the indications for suction curettage, aside from the general considerations which have been enumerated? The chief ones may be enumerated as follows:

1. *To determine the nature of endocrinopathic menstrual disorders.* In many cases of amenorrhea, for example, the study of small particles of endometrium taken at intervals of a week or so, first from one area of the uterus, then from another, may show an atrophic undeveloped endometrium at all examinations, indicating an absence, or a marked deficiency, of the ovarian hormones responsible for endometrial development. In other cases of this disorder, one may find evidence of a definite histologic cycle quite similar to that seen in the normally menstruating woman, except for the absence of a bleeding phase. In abnormal bleeding with entirely normal pelvic organs, a very common finding is that of hyperplasia of the endometrium, which at once establishes the functional nature of the bleeding, with hyperestrinism as the underlying factor. On the other hand, hyperplasia may be found in cases of amenorrhea of even many months' duration, for, as is well known, amenorrhea may be due to persisting hyperestrinism ("polyhormonal amenorrhea"), with only occasional bleeding at long intervals because no drops in the estrin level occur.

In general, if an endometrium is well developed, it may be assumed that it is receiving an adequate supply of its selective growth hormone, estrin, and that the follicle-ripening gonadotropic hormone of the anterior lobe is also functioning normally. In the same way, if the endometrium shows definite secretory activity, there can be no question that it is being supplied with the corpus luteum hormone, progesterone, for no other hormone can produce this effect. For that matter, there is no other way, by blood or urine studies or otherwise, of determining this point. A progesterone effect in the endometrium presupposes a functioning luteinizing hormone of the anterior lobe.

2. *To determine the occurrence or nonoccurrence of ovulation in cases of sterility.* This, as a matter of fact, was the primary purpose for

against the sides of the tube. In order to ensure good sections, the tissue should at once be transferred from the saline solution to the fixing fluid, usually formalin.

There are of course a minority of patients in whom curettage by this technic is not possible, at least without light anesthesia. Among these are the extremely nervous and apprehensive type, or those with very tiny cervical canals, or those with small, deep vaginal canals and inaccessible cervixes. In multiparous women, the procedure is almost always easily possible. For that matter, where curettage is done in connection with other operative procedures requiring anesthesia, I have come to use the suction curette almost as a routine, for there is rarely any therapeutic need for dilatation, and the curettage can be just as thoroughly done by the suction curette as by the ordinary curette, which calls for preliminary dilatation. If one doubts the thoroughness of the curettage by this method, one can be readily convinced by following the suction curette by any of the ordinary uterine curettes. Usually no additional tissue is obtainable.

Suction curettage by the above-described technic is commonly accompanied by very little pain, though the occasional patient may complain considerably. The whole operation, however, rarely requires more than a minute or two, so that there are few patients who would not prefer this brief discomfort to the alternative of even light gas anesthesia and usually hospitalization. When possible, and this is usually the case, traction on the cervix with a tenaculum should be avoided, as this will cause pain through transmitted traction on the sensitive visceral peritoneum.

Following the operation, patients are allowed to rest for a short time, though practically all of them within a half-hour feel quite fit, so that they are taken home from the hospital or office in an automobile, with instructions to rest in bed for a day or two. I know of no theoretical risk in such a plan, and certainly there have been no unpleasant sequelae in any of the rather large series of patients whom I have treated in this semiambulatory way. To urge the plan as the routine form of diagnostic curettage would be absurd, for there are still many patients who, through their own preference or because of some reason in the surgeon's mind, should be curetted in the traditional and more deliberate fashion. But even a day or two in the hospital, plus operating room and anesthetic fees, constitute a not unimportant economic item to some patients, many of whom will be grateful if the desired information is obtained by simpler and less expensive means.

The dangers of suction curettage are those of curettage in general. Carelessness or the use of force in introducing this instrument, like the ordinary uterine curette, might result in perforation of the uterus. So far as I know, this accident has not occurred with the suction curette, though it has been used extensively in a number of clinics and by a

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ical measures. In at least some cases, this can be done by the suction curette, thus avoiding the necessity of repeated hospitalization. In cases of functional bleeding, a readjustment of endocrine balance occurs after a stormy bleeding career of varying length, and the repetition of suction curettage, with the temporary cessation of bleeding which it practically always brings about, will help the gynecologist to tide patients over this period of endocrine upset until the hoped-for readjustment occurs.

CONCLUSIONS

The suction curette is of frequent value in the study of both functional and anatomic gynecologic conditions. It is usually possible, and often a real advantage, to employ it without anesthesia and without hospitalization. This method of curettage is not feasible or advisable in all cases, and the traditional operation of "D & C" is still preferable, or necessary, in a considerable group. But the field of usefulness of the instrument is a rather wide one, and one which many gynecologists have overlooked.

which the suction curette I have described was devised. It is now well established that, in a small proportion of women, essentially normal menstruation may occur without ovulation. Cases of this anovulatory type are most frequent in the early and in the late years of menstrual life, though they are also at times encountered at other age periods. The practical importance of this observation, as I have emphasized in various papers, is in relation to certain cases of sterility which are not explainable by any other discoverable cause.

To determine this point, endometrial tissue is obtained, usually by complete suction curettage, just before the expected date of menstruation, when the endometrium normally presents the striking secretory changes produced under the influence of the corpus luteum hormone. If, instead of such a picture, the mucosa shows a clearly nonsecretory appearance—and this may be checked up by differential glycogen staining—it may be assumed that no progesterone is being produced, i.e., that there is no corpus luteum in the ovary and that the woman has not ovulated, at least during that particular cycle. If ovulation does not occur, pregnancy is obviously impossible. Such "ovulation" tests, therefore, performed usually by the suction curette, have become a part of the search for the causes of sterility, especially when other studies, such as basal metabolism determination, tubal insufflation, examination of the husband, etc., have thrown no light on the problem.

3. *Diagnosis of pathologic lesions.* This is particularly important in the differentiation of causes of uterine bleeding. I have already spoken of the frequency with which, in cases of intramterine bleeding in women with normal pelvic organs, the endometrium yields the typical hyperplasia which establishes the endocrinopathic nature of the bleeding. On the other hand, much more serious lesions may be revealed. In two of our cases, unsuspected tuberculosis of the endometrium was disclosed, subsequent operations confirming the presence of the disease, not only in the uterus, but also in the tubes. Again, in a number of cases of postmenopausal bleeding, suction curettage has shown definite adenocarcinoma. In suitable cases of postmenopausal bleeding, a plan which I often follow is to do a preliminary suction curettage without anesthesia, followed by microscopic examination of frozen sections if the tissue is sufficiently abundant or suspicious, proceeding at once with the radical operation if adenocarcinoma is revealed.

4. *Occasional therapeutic value.* As with ordinary curettage, functional bleeding may be cured by suction curettage. On the other hand, in the majority of cases, functional bleeding occurs after a variable length of time. In young women, where radiotherapy is undesirable, such recurrent and frequent profuse bleeding often constitutes a trying problem, especially if, as is frequently the case, organotherapy is found to be unsuccessful. In many of these cases, a repetition of the curettage at intervals often will be preferable to radiotherapy or other rad-

The large defect of the scalp was then immediately covered by cutting long and wide Thiersch skin grafts from the thigh. It was possible to cover this large defect with only three pieces of Thiersch



Fig. 1.—Showing massive congenital fibromatous pigmented mole of scalp.

grafts. The edges of the graft were not completely brought up to the margin of the scalp but only close to the margin of the scalp, leaving an interval of about one-eighth inch. This interval is important, as it allows the scalp to grow down to the Thiersch graft, rather than the

MASSIVE CONGENITAL FIBROMATOSED PIGMENTED MOLE OF SCALP*

HERBERT WILLY MEYER, M.D., NEW YORK CITY

IT IS surprising how frequently physicians allow patients to go for years with lesions which are not only cumbersome to the patient, but also quite distressing for themselves and others to see. Still such is the case, and we occasionally have the opportunity of seeing interesting lesions which present some interesting problems in their treatment.

In August, 1927, I had the opportunity of seeing a young man, twenty-two years of age, who had a large tumor on the scalp which he had had all his life (Fig. 1). It had slowly increased in size and thickness, and he had consulted many physicians and surgeons in various cities and clinics. Radium was used by one without any effect whatsoever. Other surgeons had taken x-rays of the scalp and advised against operation, stating that they thought surgical removal would be impossible and dangerous. This deformity, which necessitated the continuous wearing of a cap while at work to cover the ugly growth, was a constant source of unhappiness to him through college and a tremendous handicap to his professional advancement in journalism.

Upon examination it was found that there was a hard, firm growth of the scalp, extending from the right forehead backward to the occiput, and from the midline down to the ear and the mastoid region. Its surface was convoluted, and here and there were some hairs growing from its surface. It was not a compressible growth, and it seemed to move with the scalp and not to be connected with the underlying perieranium. We, therefore, urgently advised the young man to have the lesion removed by surgical excision. He was operated upon at the Lenox Hill Hospital in October, 1927.

The operation was performed under colonic ether oil anesthesia. The incision was made through the scalp, allowing about one-fourth inch margin from the edge of the tumor, after the circumference of the tumor had been injected with 1:10,000 adrenalin solution for better hemostasis. The incision was carried down to the perieranium, and a plane of cleavage was entered between the lesion and the scalp, permitting a quick and safe removal of the entire growth with very little accompanying hemorrhage (Figs. 2 and 3).

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Thiersch graft to heal up to the edge of the scalp. If the epithelium of the scalp grows down to the Thiersch graft, a flat, smooth wound

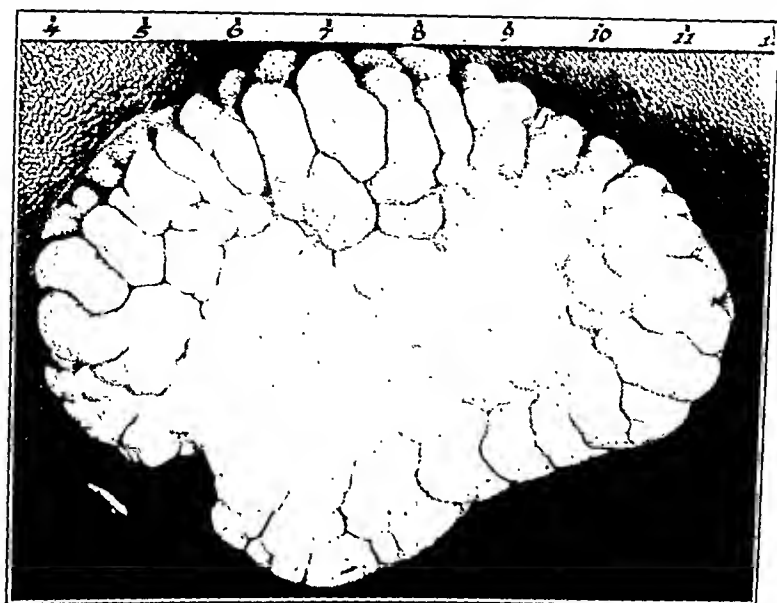


Fig. 2.—Shows outer surface of tumor after removal.

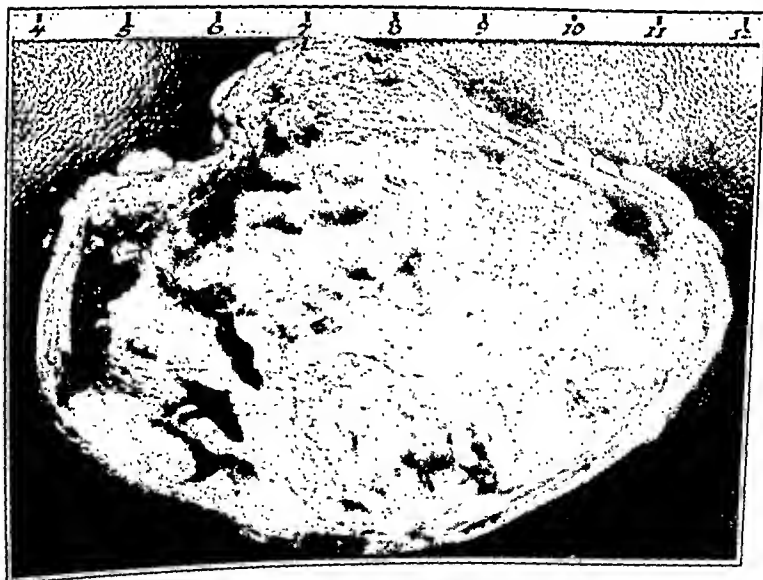


Fig. 3.—Shows inner surface of tumor after removal.

edge is obtained, while a graft placed up to the edge of the scalp gives immediate healing, but there will be a sharp, raised margin to the

wound. The raw surface between the Thiersch graft and the scalp was covered with a strip of iodoform gauze, well washed out and dried between gauze compresses to rid it of the excess moisture. The Thiersch grafts over these large areas were covered with plain sterile gauze and no silver foil. (We have given up the use of the silver foil over the grafts, as it does not seem necessary and occasionally gives an ugly dark silver stain to the graft.) The most important part of the dressing of the graft is the application of sterile adhesive strips which must be placed in every direction to counteract any stress or pull and to prevent any displacement whatsoever of the graft. The whole surface of the dressing must be covered with interlocking strips of adhesive. Following this, a compression dressing is applied.

The area on the thigh from which the Thiersch graft was taken was covered with twelve to fourteen layers of silver foil covered by gauze and adhesive strapping. This dressing of the thigh must be left in place for two weeks when it may be removed and the area usually is completely healed.

The patient made an uneventful recovery. On the sixth day the first dressing was done, and it was found that the Thiersch graft had taken successfully. A small strip of gauze with one per cent fuchsin ointment was then placed along the edge, and it took about two weeks for the scalp to grow down to the edge of the graft (Figs. 4 and 5). As soon as the grafts had completely healed, he began to wear a partial wig fastened on to the scalp with the typical wig adhesive. From a distance it is not easy to see that the patient is wearing a wig over half of his head. He returned to his work a healthier and certainly a happier man. It is now nine years since the operation, and there has been no recurrence (Figs. 6 and 7).

The pathologic examination of the specimen showed that it was a congenital fibromatosed pigmented nevus of the scalp. It measured 20 by 15 by 8 cm. The skin over most of the growth was thin and loose, but the deeper structures were very hard. The edges of the tumor faded off into normal scalp tissue. On cutting through the growth, a gritty sensation was experienced, and the cut surface revealed a dense, white, fibrous tissue with areas of calcification.

Microscopically, examination showed skin and subcutaneous tissue to which was attached a small amount of voluntary muscle. The surface of the skin was convoluted, and the epidermis appeared to be intact, though varying in thickness in different parts, being thinned out in places, and hypertrophic in other places. The dermis and subcutaneous tissue showed marked overgrowth of fibrous tissue which had largely replaced the fat of the latter tissue. The fibrous tissue was for the most part very dense and composed of compact bundles of fibrils and relatively few small compressed spindle cells. This tis-



Fig. 4.—Anterior view with healed Thiersch grafts on scalp.



Fig. 5.—Lateral view four weeks after operation showing healed Thiersch grafts in place.

MEYER: MOLE OF SCALP



Fig. 6.—Anterior view one year after operation. With wig.



Fig. 7.—Lateral view one year after operation. With wig.



Fig. 4.—Anterior view with healed Thiersch grafts on scalp.



Fig. 5.—Lateral view four weeks after operation showing healed Thiersch grafts in place.

LA METTRIE

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"La Mettrie . . . cet fut un philosophe, sans cesser d'être un médecin."
—De Vizeaux.

THE number of medical men who may be counted in the world's group of creative philosophers has been relatively small. It is not that the average physician does not philosophize, for the very nature of his calling continually compels him to build up a ready-made metaphysics, a protective "defense mechanism," as it were, which will enable him to believe or disbelieve in his own medicines and in their respective values. One would think that doctors would attempt to go further and seek a correlation between life and death, the two commodities with which they constantly deal. But this has not been the case. Undoubtedly many have tried to do so, but, for one reason or another, have wandered off into literature, politics, and art. A limited few, however, have succeeded in remaining faithful to their profession and, in addition to becoming outstanding investigators in anatomy and physiology, have sought to combine in some fashion or another the spiritual and physical components of man. Maimonides, Bacon, and Avicenna were three such individuals of the Middle Ages; William James is one of our own times. A study of the philosophers of the eighteenth century will reveal two of this group who stood out as pioneers, the English surgeon, John Locke, and Julien de la Mettrie, the Father of Materialism.

The Frenchman, a weird mingling of many emotions and ideas, an individual who was "no small cypher in the ranks of the Aselepiadae," attempted single-handed to change the prevalent religious and philosophical ideas of his age. The Breton was brave enough to express his ideas forcefully, and, it must be admitted, quite tactlessly, and soon aroused the jealousy of his professional confreres and the wrath of those in high places. The results of his hopeless struggle were what might be expected, and, indeed, the terse epigram of Epicurus, "It was to philosophy that I owe my worldly ruin and my soul's prosperity," had no better example than La Mettrie's life.

Men have been affected to a greater or less degree, one way or another, by their parents' wishes and station in life, by their early

sue showed continuous hyaline degeneration. Embedded in the deeper parts was an island of compact bone. Scattered through the tissue and most abundant in the outer part were nests, vertical strands, and irregular masses of atrophic nevus cells, a few of which contained yellowish brown and blackish pigmented granules. Most of the hair follicles and sebaceous glands had disappeared, and the persistent ones showed varying degrees of atrophy. There was no evidence of malignancy.

CONCLUSION

This was a congenital benign tumor of the scalp in a young man, twenty-two years of age, who had sought relief of this deformity for many years. There is no question but that an earlier operation performed along the same lines as the one reported would have relieved this patient of a great deal of mental worry and unhappiness. It behooves surgeons to urge early operation for such lesions.

La Mettrie, doubtless on the advice of his friend, went off to the medical school at Reims,* which was one of the best in the century. Here in 1728, the ex-theological student obtained his "bonnet de docteur." He was now nineteen years of age, still too young to practice, and, as was the fashion of his day, the young doctor proceeded to Leyden, the University of the great Boerhaave, then the leading medical man of the world. Indeed, his fame was so great that letters addressed "Boerhaave, Europe" would always reach him. The Dutchman was



E. Selle, sculp.

H. Somers

JULIEN OFFRAY de la METTRIE

Fig. 1.—Reproduction of likeness of La Mettrie, taken from Quépat's work by Helene Somers Millar.

an authority on many things and, curiously enough, among his many accomplishments, prided himself on being a critic of Spinoza and Hobbes.† And so while the great educator poured chemistry, botany, and "practical medicine" into students who attended his lectures, he

*It was about this time that several American Colonials attended the University. The most famous was John Jones, author of the first surgical manual written in America.

†Boerhaave had actually received his doctorate for his dissertation "De Distinctione Mentis a Corpore," in which he openly opposed the doctrines of Epicurus, Hobbes, and Spinoza.

religious training, and by the age and generation of the world into which they were born. All of these factors had a great influence in the life of the doctor-philosopher.

The famous materialist was born in St. Malo, a town later to give Chateaubriand to the world, on Christmas Day, 1709, six scant years before the death of Louis XIV. His family has been described as "noble but poor and impoverished," and for financial reasons they had been compelled to enter trade. In the days of the Golden Emperor, such a move was practically tantamount to social suicide and undoubtedly the La Mettries received many sneers and slights from their more fortunate aristocratic brethren. Such conditions would tend to develop much ready-made materialism.

The time came shortly to consider the matter of a formal education. Already the young lad was a facile talker, and hopes were entertained by his parents that their son would enter the church. A malicious historian has said that Julien's verbiage was the principal reason for their pious wish. To this end, the growing boy was sent first to the school of Coutances, where he soon won prizes in rhetoric. Thence he proceeded to Plessis in Paris to study logic, and it was here that the youth came under the magnetic spell of one of the professors, Cordier, a nationally known Jansenist. A few words in passing may be necessary to explain the ideas and tenets of this intense, fanatical, religious sect. Briefly stated, this group brought the principles of St. Augustine up to the eighteenth century. They stated that a belief in the helplessness of man and his utter dependence on his Maker were ever necessary. They argued that no amount of church going and ceremonial could save man, and the group rejected justification by faith as impossible and declared that while conversion might be instantaneous it was only the beginning of a long and gradual process. Nevertheless, their religious leaders held that a personal relationship of the human soul to God existed and that mediation could only be gotten through the Roman Catholic Church.

The pliable mind of the serious lad, influenced by this strong, forceful teacher, was much impressed by such reasoning.

From Plessis the young student went to Hareourt for a course of "natural philosophy." It was about this time that La Mettrie began to turn back from his ideas of becoming a priest, and as Frederiek the Great has so aptly stated, "On persuade le père, on l'assura que les remèdes d'un médecin médiocre rapparteraient plus que les absolutions d'un bon prêtre."

And so from the priesthood, the Breton turned to medicine. In this step he was undoubtedly influenced by Huanald, the village physician, whom La Mettrie greatly admired and respected. Specific training, more than one would get by attending the daily rounds of a small town practice, was thought advisable. Consequently,

soon to find formal expression in his books. Not that he had not been engaged in practical research before this, for it would seem from all accounts that he was anything but an armchair researcher! Several anecdotes have been told about his investigations. Once, indeed, the grooms of his regiment assaulted their medical officer and beat him severely. In fact, they almost killed the Breton before he was rescued, so much did these servants resent his guinea pig technic on their associates and on themselves. Still the medical officer's work for his superiors was satisfactory, for, even if his inferiors hated and feared him, he was in due time promoted and given the responsible position as chief to several base hospitals which were located in Flanders and the Low Countries.

La Mettrie was one of those individuals who needs must write, but with his pen he almost always seemed to succeed in creating trouble for himself. One of the first of the young author's works, written in St. Malo, was his *Observations de Médecine pratique*, which was followed in 1735 by a translation of Boerhaave's *L'Aphrodisiacus*, to which he added a few comments and observations of his own on the nature of venereal diseases. A year later, Astruc, of Paris, published his *De Morbus Venereis*, in which he spoke appreciatively of the work of the young medical man, but also called attention to several errors of translation that had been made. In 1737, the Breton's *Traité du Vertige* appeared, and, in 1739, his *Nouveau Traité des Maladies Veneriennes* appeared. Astruc still took occasion to "sharpshoot" and criticize the works of his rival. Rapidly numerous lampoons and satirical papers appeared throughout France which were insultingly frank and which seared with the branding iron of caricature. Many of these were purported to come from La Mettrie, and some of them doubtless did. In them the entire Parisian medical profession was ridiculed to high heavens. Almost no one was spared, least of all Astruc.

This war of pen and pamphlets was stopped perforce for a period when the Guards moved off to war. But once the Frenchman was back to barrack life, his urge to write seized him again. It was soon after his appointment as Medical Chief of half a dozen hospitals that the army officer really drew fire from almost everyone. This time not only were the mediceos opposed to him for the very obvious insults leveled at them, but in a very short time the Roman Catholic Church, the several Protestant faiths, and the French Throne rose against this defiant author. The reason—principally—his *Natural History of the Soul*, which was shortly followed by other books of even more materialistic and apparently more atheistic persuasion. At any rate, all of them aroused tremendous bitterness and feeling against their creator.

These volumes were immediately condemned; first by the army chaplains, and then by the high church authorities in the *Index Expurgationes*. So much pressure was brought to bear on La Mettrie that he

undoubtedly found time to explain the subtleties of pantheism and materialism as expounded in "The Ethics," "De Corpore," and "Leviathan" to a few of his favorite disciples.

But there comes a time when theory must give place to actuality, especially when a young man must think of food, and when one's parents become fatigued and wearied of providing tuition and "running expenses" for peripatetic collegians. Back to St. Malo came the twenty-four-year-old physician full of ideas, with one of the best theoretical professional educations possible for his time, to plunge into the sorrows and griefs of a general practice. But the ex-student's mind lingered with the academic, and he had no desire to lapse into marmoreal dullness. He found time to translate Boerhaave and, with the bland egotism of youth, even to compose a brochure on practical medicine. Hunauld died shortly after his assistant returned. Instead of settling down and building up a safe and lucrative practice, as any unimaginative man would have been glad to do, the ambitious La Mettrie suddenly, after three years in the tiny village, gave up his place and set off for Paris. In this city, the country doctor apparently had enough influence to secure a commission as medical officer with the French Guards, chiefly, it would seem, through the benevolence of Morand, the surgeon to the Invalides, and the Duc de Grammont. Most nonmedical historians have called La Mettrie a military surgeon. This he apparently was not, in the strictest sense of the word, for, as Bonnette has pointed out, the few regiments of the time who possessed medical assistants had no less than three varieties, doctors or medical officers, surgeons, and apothecaries, and these all had sharply defined duties and professed great contempt for anyone who was not of their own narrow professional sphere.

La Mettrie was in the prime of his life when the Silesian Wars between Maria Theresa and France began, and his regiment was moved to the East. The Army soon saw active service. As a medical officer, he participated in the battle of Fontenoy under Marshall Saxe.* In this fight, one of the outstanding points of the combat was the charge of the Guards Brigade against the Gardes Français. Whether or not, as the story goes, the polite Frenchmen really asked the opposite side to fire first may well be disputed. The casualties of this bloody encounter were tremendous. Fifty officers and 760 men of the first regiment fell, and the losses of the other troops were equally severe. Among the dead was La Mettrie's Colonel and benefactor, Grammont.

Action was seen again in Dettingen, and the Médecin was also present at the siege of Freiburg, where the young officer was stricken with a severe fever. During his convalescence, the sick man began to think about the soul, about life and their causal relations—ideas which were

*The famous general at that time was suffering from a dropsy so severe that he was unable to ride a horse and was confined to a wheel chair!

La Mettrie picked up mechanism, as Durant writes, "Where the frightened Descartes like a boy who has burned his fingers had dropped it, and announced boldly that all the world not excepting man was a machine."

F. A. Lange declares that La Mettrie was one of the most abused and least read men in the history of literature and called him the "scapegoat of French materialism in the 18th Century." As Frederick the Great has said, the priests insisted on finding "seeds of heresy in a work-dealing with physics."

Given the hypothesis that the so-called higher activities, that is, the soul, the memory, the passions, and feeling, are of mechanical and materialistic origin, then man becomes a machine and "self love is a virtue, crime a disease." The soul is merely the thinking part of the body, and, at death, it, too, passes away. The soul may therefore become diseased. For examples of this, we have the case of the paralytic who asks if his leg is still in bed with him, of the soldier who thinks that he still has his amputated arm. Mental twists are described; people who believe that they are werewolves, cocks, vampires, "and the man who maintains that his nose is of glass and who has a continuous compulsion to sleep on hay in order that his proboscis may not be smashed." Other changes follow circulation if it be too fast, and one should remember that a good meal and drink have well-known effects on the soul. Again, raw meat, which "makes animals fierce" and which would have the same effect on men, is mentioned for its effect on the passions. This is so true that "English who eat meat red and bloody and not as well done as ours seem to share more or less in the savagery due to this kind of food and to other causes which can be rendered ineffective by education only . . ."

The transition from animals to men is not violent, as true philosophers will admit. If those who are born deaf can be taught, why cannot the ape? La Mettrie goes further. He favors frank atheism, for the Frenchman believes that the existence of God has been unproved and is practically nonimportant for our existence. Argument from design becomes ineffective against the hypothesis of mechanical causality. "Man is so complicated a machine that it is impossible to get a clear idea of the machine beforehand and hence impossible to define it."

After an examination of life the philosopher is perforce limited to the one thing about which it is possible to know, that is, the human body.

The physiology of the eighteenth century was sketchy, to say the least. Briefly speaking, the circulation of the blood was known, but respiration was ignored, and the functions of the nervous system were

was forced to resign from the Army and flee to Leyden. Even here he was not safe. Again at night, on foot, and in seerecy, the hunted author was obliged to leave this city. The brilliant, caustic man was at the end of his resources until his compatriot Maupertuis took occasion to speak to Frederick the Great about him, and the soldier-philosopher was formally invited to come to Berlin. This the outcast was happy to do and, in 1748, was personally received by the cordial King who immediately made him a reader and pensioned him with enough money for his immediate needs. Once more there was time to write, and directly there appeared the *Memoire sur la Dyssentérie* and the *Système d'Épicure*. No longer hunted from pillar to post, he had time for leisurely conversation and banter with the court savants, d'Argens, d'Algarottis, and Voltaire among others. With the last individual, little love was lost. Probably each one was jealous of the other's supposed influence with the Emperor.

But all was not satisfactory in Berlin. We have Voltaire's word that La Mettrie had asked him to intercede with the Parisian authorities on his behalf. The author of *Man a Machine* was human enough to be homesick and, with a sentimentality quite unnecessary in a true materialist, continually longed for his native land.

Just what is the essence of his philosophical works? Today we get no spinal thrills at his ideas, as they are openly accepted, or at least tolerated, by the majority of our generation. But they were diametrically opposite to the harsh, metallic minds and the generally accepted ideas of his day. For an illustration of the power and mentality of the Catholic church of that century, two cases may be cited:

As late as 1748, a woman in France was fined 3,000 francs because she dared to employ a Protestant midwife. Again, in Toulouse, no one who was not a member of the Catholic church could be a lawyer, physician, apothecary, printer, bookseller, or grocer. So much for the narrowness of the time, though it must be admitted that it was not unlike certain contemporary countries of today. It was HERESY spelled in capital letters to have a man "prove" to his own satisfaction, at least, and in print where all might see and read, the fact that "nature was amoral," as well as to state loudly, "Why should one believe in a providential nature? We have not one proof; the greatest chance favors the contrary opinion." Authors of such ideas were dangerous to State and Church, and they should be immediately and completely destroyed and uprooted. So argued those who wore the royal crowns and cardinal caps. But La Mettrie was first a true "doctor of observation," and, although for this trait he openly acknowledges his debt to Boerhaave, he had the courage to go on and to take up Cartesian materialism and apply it without qualification to the human body.

first magnitude, and a gay devil who frankly liked his leisure, La Mettrie would be found every afternoon sprawled half-dressed on his couch, wholly at ease and always ready for any form of cultivated lechery that might suggest itself. An acknowledged libertine and rake, who though married to Louise Charlotte Dreano, by whom he had at least one legitimate child, he was known to have at least one "fille de joie" in Berlin whom Frederick the Great actually pensioned upon her lover's death.

It was an ironical twist of fate that two of the things of which he was really passionately fond, the practice of medicine and his gastro-nomic athletics, were to be the immediate causes and reasons for his death. The accounts of the final illness vary somewhat in detail, but it would seem that La Mettrie, on a bet, gulped down an entire pheasant pastry pie, after a many course banquet at the house of MiLord Tyrconnel, the English ambassador at Berlin. Shortly after this awe-inspiring feat, the King's Reader was seized with what appeared to be botulism, an outcome not surprising when one reads a description of this "snack of pastry," for it was made of "eagle disguised as pheasant, which had arrived from the North, with plenty of bad lard, pork hash, and ginger in it. . . ." At any rate, the attending German physicians advised purges. To this the sick man violently disagreed. "Bloodletting was the procedure of choice here," he gasped between cramps, and ordered repeated venesections. Reluctantly they complied with his wishes, and the Frenchman was bled no less than eight times.

At the moment of death, an Irish priest, a Father MacMahon, chaplain of the Ambassador, desired to convert La Mettrie and elbowed his way into the death room. The dying man would have nothing to do with him, but the Father persisted in sitting down and waited expectantly by his bedside. To quote Carlyle again: "La Mettrie in a twinge of agony cried out, 'Jésus Marie!' 'Ah, vous voilà enfin retourné à ces noms consolateurs,' exclaimed the Irishman. To which La Mettrie answered, in polite language, to the effect 'Bother you!' and expired a few minutes after. . . ."

Before his death, the philosopher had requested that he be buried in the garden of the Ambassador's grounds, but this wish for unhallowed ground was not respected, and the bloated body was carried into a Catholic church. The priests had beaten him in the end!

Frederick the Great gave the eulogy before the Berlin Academy, and his speech has been preserved to the present time. It is the usual type of panegyric and is, in many respects, like the annual Elk Club requiem given in our small American towns of today, the kind of stuff that nobody, not even the orator, bothers to take very seriously. But

*Thomas Carlyle's translation of Voltaire's letter to Madame Denis.

only touched by all physicians, if at all, in an extremely rudimentary fashion. It was held that "animal spirits" animate the "nerves, more or less fluid, more or less rapidly." Of the genital systems, scarcely anything was known save the fact that the union of the sperm with the egg would cause conception. La Mettrie wished to correct ignorance among his professional brethren, and stressed the need for autopsies and skill in pathologic anatomy. The old pupil of Boerhaave guessed at the origin of nerves and argued that each nerve carries "impressions" to a special region of the nerve center. "The brain has its muscles for thinking as the legs muscles for walking." The Frenchman knew that irritation of the optic nerve gave symptoms of light. Drugs were discussed with their effects on the human mind: opium which paralyzed wishes and stimulated the imagination, coffee which excited and animated conversation, and the value of good food and wine on a drooping spirit. The Breton worried about gastric fermentation and of it said, "No air, no fermentation." The various effects of climate are mentioned. The idea of irritability has been generally credited to Haller's *Eléments de physiologie* (1761), but in *L'Homme Machine*, we find that:

"Life principle does not find in the soul the material consciousness; this is not in the whole but in the separate part and each fiber is stirred by it." Ten examples are given to prove this contention but space will permit but four to be mentioned here: (a) The flesh of animals continues to palpitate after death, e.g., tortoises and lizards. (b) Muscles separated from the body will contract when excited. (c) Injections of warm water will resuscitate the heat in the muscles, according to Cowper. (d) The heart of a frog will move one hour after separation from the body. . . .

A hint at evolution is made by this amazing writer, but even more interesting is the explanation for epidemics which he said are caused by "seeds" which "come from the air." The work of Leeuwenhoek is cited, and the boiling of water is recommended as an excellent means of purifying water. This was over one hundred years before Pasteur's work was published.

Personally La Mettrie was not a gentleman with a cream puff soul. The philosopher is described as "un homme vigoureux," an individual who always seemed to be laughing, his enemies declared sneering, and it was with this ever quizzical, and often sardonic, countenance that this dauntless hedonist faced an intolerant, reproving world. During the greater part of his life, except for a few bad months when he had been compelled to leave Leyden, the Frenchman had enjoyed a glorious, carefree existence. Doubtless a sexual virtuoso in keeping with the fashionable men of his day, undoubtedly a gourmet of the

Editorials

Surgical Complications of Amebiasis

AMEBIASIS is likely to be considered by most physicians as a condition which occurs principally in tropical or subtropical localities and which is of little surgical interest. That the former concept is incorrect is borne out by the fact that since the Chicago epidemic, which probably only served to make the profession "amebic conscious," amebiasis is being detected in many of the northern, eastern, and western localities of the United States. In a series of 49,336 persons examined in all parts of the United States and collected by Craig,¹ 5,720 (11.6 per cent) were found to be infected with *endamebic histolytica*. Craig² found in examining 189 physicians from all parts of the United States *E. histolytica* in 12.7 per cent. Unquestionably amebiasis occurs ubiquitously. That amebiasis is of surgical importance is attested by the fact that surgical complications occur not infrequently.

Surgical complications of amebiasis are more likely to occur in the absence of dysentery than in the cases in which this clinical manifestation is present. A probable explanation for this fact is that when manifested by dysentery the amebic infection is more likely to be recognized by the clinician and adequate therapy instituted before the development of the surgical complications; whereas in those cases in which dysentery is absent, the underlying lesion of the bowel is likely to be overlooked, because the complicating lesion produces the clinical manifestations.

Probably one of the most frequent surgical complications of amebiasis is amebic appendicitis, which may occur as an acute suppurative or a chronic inflammatory process. In both instances, the true nature of the lesion is likely to be overlooked unless the physician considers the possibility of its existence. This is particularly true in the low grade chronic infections, and unless careful examination of the feces is made, the true nature of the condition is missed. The frequency of the acute amebic inflammatory processes in the appendix is demonstrated by the investigations of Clark,³ Strong,⁴ and Craig,⁵ who obtained 7 per cent, 40 per cent, and 16 per cent incidences, respectively, of suppurative appendicitis in fatal cases of amebiasis. Although the incidence of the subacute and chronic inflammations of the vermiform appendix produced by the *E. histolytica* is more difficult to determine than that of the acute inflammations, it probably occurs much more frequently than is generally considered. So frequently does this condition exist that it is the rule in the author's clinic to have a careful stool examination for

in a letter to Wilhelmina, the same month of his reader's death, November, 1751, the Emperor writes, little expecting that it would ever be compared with his formal speech:

"He (La Mettrie) was a good doctor and a very bad author; by avoiding to read his books one could manage to be well content with himself!"

The author wishes to thank Helene Somers Millar for her reproduction of La Mettrie taken from Quépat's work.

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the anteroposterior roentgenogram and obliteration of the anterior costophrenic angle in the lateral view. In contradistinction to these findings, obliteration of the lateral costophrenic angle in the anteroposterior roentgenogram and the posterior costophrenic angle in the lateral view is indicative of subphrenic abscess not associated with amebic suppuration.

Treatment of uncomplicated amebic hepatic suppuration consists of simple aspiration combined with the use of amebicides. Open drainage is to be condemned except in the presence of secondary infection, because as in an uninfected tuberculous abscess, open drainage is always followed by secondary infection with its disastrous results. The soundness of this contention is substantiated by the results obtained in a series of 4,035 cases collected from the literature in which, following an open operation, there was a mortality rate of 47.2 per cent; whereas in a series of 459 cases in which the conservative treatment was used, the mortality rate was 6.9 per cent. In Ochsner and DeBakey's^{6, 7} series of cases, the open operation in 46 cases was attended with a 19.5 per cent mortality; whereas in 24 cases in which the conservative treatment was used, the mortality rate was 4.1 per cent. In cases in which secondary infection has already occurred as determined by culture and examination of the aspirated pus, open drainage is indicated and desirable. These cases are extremely rare, however, as secondary infection is usually the result of the entrance of microorganisms *following open drainage*.

Another complication of amebiasis, although frequently not considered, is pleuropulmonary involvement. In the 59 cases studied by Ochsner and DeBakey,⁷ 7 (13.5 per cent) were uncomplicated by extension to the pleura or lung. In reported series of 2,490 hepatic abscesses, pleural complications occurred in 7.5 per cent and pulmonary complications in 8.3 per cent. In the series from the Charity Hospital and Touro Infirmary, 10.5 per cent of the hepatic abscesses were attended by pulmonary complications and 5.2 per cent by pleural complications. Pleuropulmonary complications are manifest by cough and expectoration, which were present in 95.2 per cent of Ochsner's cases. Other manifestations are fever, thoracic pain, right upper abdominal pain, diarrhea. The expectoration of "chocolate-sauce" pus is almost pathognomonic of the condition and always indicates a bronchohepatic fistula.

As in amebic infections of the liver, conservative treatment in pleuropulmonary complications, particularly the pulmonary ones, is important. In a group of cases collected by Ochsner and DeBakey,⁷ the mortality rate in those cases in which amebicides alone were used was 5.4 per cent. In those cases in which the patient was operated upon and emetine used, the mortality rate was 16.6 per cent; whereas in those cases in which open drainage alone was used, the mortality rate was 48.2 per cent. In cases, however, in which an amebic abscess of the liver has ruptured into

E. histolytica in all patients in whom a diagnosis of chronic appendicitis is made. Probably the appendiceal infection is only a part of a more or less generalized involvement of the intestinal tract. In approximately 10 per cent of these cases, the parasite is found; and in most of these instances, antiamebic therapy is sufficient to bring about a relief of all symptoms and signs.

The second most frequent surgical complication of amebiasis is hepatic abscess, which results from the invasion of the liver following the transportation of amebas to it through the portal vein. The relative frequency of this complication is shown in an analysis presented by Ochsner and DeBakey^{6, 7} in 1935. During the period 1928 to 1933 inclusive, there were 574 patients diagnosed as having liver disease in the Charity Hospital in New Orleans, of which 14.6 per cent had liver abscesses and 10.2 per cent had amebic abscesses. Amebic involvement of the liver occurred much more frequently than these figures indicate, because those cases with amebiasis which responded to amebicides without destruction of liver tissue had amebic hepatitis without suppuration. In a series of 4,392 collected fatal cases of amebiasis, 37.9 per cent were complicated by hepatic suppuration; and in the Charity Hospital cases, amebic abscess complicated amebic dysentery in 15.2 per cent. Of 102 cases of liver abscess admitted to the Charity Hospital and the Touro Infirmary during this period of time, 73 (71.5 per cent) were amebic abscesses and 29 (28.4 per cent) were pyogenic. The fact that amebic suppuration of the liver can occur without an antecedent diarrhea is demonstrated by the findings in the above mentioned series in which a positive history of previous diarrhea was obtained in only 59.6 per cent, and in which diarrhea was a symptom at the time of admittance to the hospital in only 19 per cent. As mentioned above, the probable reason for the high incidence of amebic hepatic suppuration in the absence of diarrhea is that the original amebic infection of the bowel is overlooked and not treated, which permits the amebas to gain entrance to the liver through the portal system. Probably in such cases the amebic infection is limited to the right side of the colon, the left side being uninvolved so that there is absorption of the increased intestinal secretions from the diseased right bowel.

Typically a patient with amebic hepatic suppuration complains of pain in the right upper quadrant of the abdomen, has a moderate degree of fever, and almost always has an enlargement of the liver. The laboratory examination is quite characteristic in that there is moderate leucocytosis without a proportionate increase in the polymorphonuclear leucocytes as is seen in pyogenic infections. Of greatest value is the x-ray examination which, as demonstrated by Granger,⁸ shows in uncomplicated liver abscess a bulging of the diaphragm, and a pointing upward into the lower lung field. Whenever there is associated involvement of the subphrenic space, there is obliteration of the cardiophrenic angle in

Preoperative and Postoperative Care

TO CARRY a patient safely through an operation with a minimum discomfort, with perfect healing of the wound, and with ultimate recovery is the hope of every surgeon. To reduce the inescapable risks to a farther and farther receding minimum should be his constant endeavor.

Nutritional experiments have long since revealed the remarkable lowering of resistance to infection and to respiratory disease following vitamin deficiencies. To operate upon patients from the "submerged half" of the population whose long-established diet has been overcooked stews, doughnuts, and coffee undoubtedly increases the risk of distressing and occasionally disastrous complications. Ideally, every patient should be hospitalized one or two weeks before operation with the avowed intention of improving general nutrition and of restoring the depleted store of vitamins. Practically, this is not usually possible. Nevertheless, in our clinic as well as on private services, the preoperative preparation invariably includes a few days of high-vitamin diet, rich in uncooked foods and citrus fruit juices. The importance of the adrenal body in combating infection seems established. Moreover, the adrenal body is richer in vitamin C than any other known substance. One may infer that proper function of the adrenal is dependent upon an adequate, if not generous, intake of vitamin C. Hence citrus fruits are stressed not only in the care of infection but also in its prophylaxis. Whenever possible the high-vitamin diet is amplified by the daily administration of haliver oil capsules and vitamin B tablets. In operations of election, the patient is advised to include these items in his diet for days and if possible for weeks before entering the hospital. All patients being prepared for thoracoplasty are placed upon such a regimen during the preoperative period of observation, study, or sanatorium care.

In any abdominal operation likely to produce stagnation in an atonic bowel, a comparatively empty intestinal tract is less likely to produce postoperative distention from fermentation and the resulting "gas" pains. Accordingly, a nonresidual diet is prescribed for such patients both before and after entering the hospital, preferably for a preoperative period of four to five days. Discomfort due to distention following operations within the abdomen, particularly upon the gallbladder, has been greatly decreased by this precaution.

Operations in the morning are necessarily performed after twelve to eighteen hours of fasting. A stuffed liver is notoriously better fortified to meet the unusual exigencies of anesthesia or the hepatic disturbances incident to cholecystitis and cholelithiasis. By inference, other opera-

the pleural cavity, evacuation must be obtained by aspiration. In those cases, however, in which there is a communication between the hepatic abscess and the bronchus, strict conservatism is preferable.

Occasionally a hyperplastic form of amebiasis involves the cecum and is of importance, particularly in elderly individuals, because of the difficulty in differentiating it from malignancies in this region. Ochsner has seen several cases in which such differentiation was impossible until after exploration of the lesion. In every such instance careful examination of the stool should be made for *E. histolytica* and amebicides should be used before attempted extirpation of the involved segment of bowel, because in such instances the lesion is not limited to the hyperplastic portion of the bowel.

That amebiasis can be complicated by pseudopolyposis of the colon is attested by a recent report of Anderson et al.,⁹ in which following a prolonged amebic infection there resulted a pseudopolyposis of the entire colon. This patient recovered following a two-stage extirpation of the colon.

In all cases with vague gastrointestinal disturbances, irrespective of the locality, the possibility of amebiasis should be considered because frequently a needless and at times dangerous surgical procedure can be prevented.

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—Alton Ochsner.

Large doses of morphia or pantopon are avoided so as not to abolish the cough reflex so necessary in preventing the accumulation of mucus or mucopus in the trachea. To replace the large doses of morphia at infrequent intervals, smaller doses of one-sixth grain of morphia or pantopon are given regularly at three-hour intervals when indicated to control pain, supplemented by sodium bromide or chloral hydrate by rectum, or sodium luminal or amytal hypodermically to promote rest. The control or lessening of pain permits insistence upon coughing and change of position. The patient with a slight throat rattle is encouraged without let-up until the offending pus or mucus is expectorated. In the presence of an abdominal incision, such productive coughing is aided by the firm application of a many-tailed scultetus binder. If large quantities of sputum are being raised, the foot of the bed is well elevated to assist bronchial drainage by gravity. Operations about or in the mouth, such as resection of the jaw or tongue, are performed in the exaggerated Trendelenburg position, and this position is scrupulously maintained for three to four days following operation to avoid the aspiration of infected oral secretions or blood. Even with the patient so placed, change of position from side to side is insisted upon. Voluntary deep breathing at half-hour intervals is likewise insisted upon and has largely replaced CO₂ inhalations.

Beginning with the third or fourth postoperative day, the patient is encouraged to flex and extend the lower legs forcibly against a pillow or bolster at the end of the bed (Cullen). This encourages circulation and prevents venous stagnation in the extremities, in addition to keeping the muscles fit. Without such exercise in bed, the first effort to walk after two weeks' recumbency is attended by unbelievable weakness and often temporarily disabling paresthesias.

Citrons fruit juices and a high vitamin intake are again stressed after the first three postoperative days during the full healing period.

One may safely predict that greater comfort, better healing, and more dependable, uncomplicated recovery will follow adequate nutritional preparation of surgical patients. For such nutritional preparation, one should insist whenever possible upon a much longer preoperative period in the hospital than the conventional overnight stay.

—*Emile Holman, M.D.*
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tions are similarly benefited. Accordingly, a high caloric eggnog, or a large drink of high caloric fruit juice if the patient is on a nonresidual diet, is served at nine o'clock on the evening preceding the next morning's operation. During the period of iodine preparation of hyperthyroid patients, a diet rich in carbohydrates and vitamins is prescribed, stressing as much candy as the patient can ingest comfortably. Large quantities of fruit juices and water are also administered. The high caloric eggnog on the evening preceding thyroidectomy is considered particularly desirable.

Preceding a serious operation of any nature, such as gastric resection, cholecystectomy, resection of colon, splenectomy, or amputations, the immediate preoperative period of fasting and of water deprivation by mouth is rectified by an intravenous infusion of 1,000 c.c. of 10 per cent glucose solution in normal saline. This is given in the two hours immediately *preceding* the operation. The hyperthyroid patient is never operated upon without this replenishment of liver glycogen *before* the operation, as well as after the operation when indicated. The tuberculous patient is similarly nourished before a thoracoplasty.

The preoperative preparation also includes an enema on the day preceding the operation—not the morning of operation—and an effective sedative in the evening preceding the operation. Preference is given to barbitol, 10 grains, plus sodium bromide, 30 grains; or nembutal, 3 grains; or sodium amytal or sodium luminal, 3 grains. This may be repeated the next morning two hours preceding the operation.

In the period immediately following an abdominal operation, care is taken to avoid the ingestion of any food capable of fermentation in the atonic, inactive intestinal loops. Only water is given in the first twenty-four to forty-eight hours, followed by warm tea or hot broth in the next twenty-four hours. Discomfort from gas is a rarity following appendectomy or cholecystectomy, if fermentable substances such as sugars, fruit juices, or milk are prohibited during the period of intestinal atony. If the operation is upon the intestinal canal itself, a Levine nasal tube is introduced into the stomach to avoid gastric distention. Water is permitted freely in the presence of such a tube, as it relieves the discomfort of oral dryness and is harmlessly recovered through the tube in the presence of pyloric spasm or temporary intestinal paresis.

Abdominal distention, as well as pulmonary complications, following operation, is further avoided by insisting on a radical change of position every two hours. A slight shift in position is quite ineffective. A complete 90 degree turn from back to side, and side to back is insisted upon. Occasionally a complete 180 degree turn from back to abdomen is effective in combating and preventing distention. The formerly dreaded gastric dilatation, with "coffee ground" vomitus, is no longer seen or feared following such frequent changes of position. It is only the inert, permanently supine patient in whom this complication occurs.

velopment of reasonably priced equipment entirely free from this danger has been wholly welcome. Furthermore, shockproof units have permitted the establishment of new technical procedures such as lateral views of the hip joint and proximal end of the femur, lateral and oblique views of the shoulder, angulation views of the head, greater facility in bedside roentgenography and fluoroscopy.

A remarkable improvement in the quality and durability of the roentgen tube has taken place these past few years. The adoption of the line type of focus permits us to utilize a much smaller effective focal spot with greater loads. This, naturally, results in a great improvement of detail and diminution of distortion. While these improvements have not been startling, the development of a practicable rotating anode tube promises much more. Within the past few years such an equipment has become available making it possible to make roentgenograms with a tube of exceedingly fine focal spot (less than 1 mm. effective) without prolonging the time of exposure or unduly reducing the peak voltage. Such x-ray tubes may well change our concepts about roentgenology of the spine, gallbladder, urinary tract, and other heavy parts. In the spine of heavy individuals, for example, distortion has been tremendous under present conditions. The relatively short tube-film distance, the relatively long object-film distance, together with a fairly large sized focal spot has produced vertebral bodies which in the roentgenogram appeared to be almost double their actual size. With the increase in size there is almost a corresponding decrease in detail and definition. The use of this new type tube arouses hopes for greatly improved technic in the diagnosis of pulmonary diseases as well.

Changes in the construction of the Potter-Bucky diaphragm now permit a marked increase in speed of exposure. Whereas previously it was difficult to avoid grid lines on a film even at a half-second, with a special type of grid exposures as rapid as one-fifth or possibly one-tenth of a second can be made with a fair degree of freedom from markings. This makes it possible to make roentgenograms of the chest with the diaphragm without sacrificing the speed which is so essential in dealing with the lungs. The diaphragm technic is particularly of value in dealing with surgical conditions of the thorax; the results of roentgenography in thoracoplasty cases and in lungs which are heavily infiltrated from bronchiectasis, tumor, or empyema are greatly improved by this means. The invention of a stationary filtering diaphragm (the Lysholm grid) has also made it possible to improve bedside roentgenography of heavy parts such as the hip or spine; it is easily portable and eliminates a fairly large share of the scattered radiation.

It should also be noted that wheel stretchers are now available which are radiotransparent and fit closely over a Potter-Bucky dia-

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

ADVANCES IN ROENTGEN DIAGNOSIS

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Part I

PROGRESS in roentgen diagnosis during the past five years has been extensive and in some respects important. Obviously only those changes of general interest to surgeons and of considerable significance can be considered within the scope of this article.

For purposes of clarity advances must be considered under a variety of headings; none of these are truly independent or singular as they are closely related, but convenience permits a reasonably sharp separation.

ADVANCES IN APPARATUS AND TECHNIC

The ability to do good technical work, to produce roentgenograms which are amenable to accurate interpretation, depends in large measure upon the quality and character of the x-ray equipment. The most striking change in this regard has been in the manufacture of transformers. During this period, the American producers of roentgen apparatus have changed from the mechanically rectified type of transformer to kenetron rectified machines. While this has increased, to some extent, the cost of equipment and has added additional hot cathode tubes requiring replacement, nevertheless, it represents a distinct step forward. The advantages of current rectification by means of valve tubes are much more apparent in roentgen therapy than in diagnosis; even in the latter, however, this type of current is far superior. If four valve tubes are used a fully rectified, steady, readily controllable current is produced. It is easily possible to attain as high as 1,000 ma. of current at diagnostic voltages; the output of the x-ray tube is much more steady; the type of radiation curve is far superior for use with the Bucky diaphragm.

The second important development concerns itself with shockproof installations. Despite the fact that there have been relatively few serious accidents resulting from contact with the high tension side of the x-ray apparatus, these few have been so unnecessary that the de-

Likewise lateral views of the shoulder can be obtained by the technic of Jordan-Narath^{9, 10} so that the position of fractures of the upper humerus, calcifications of the supraspinatus and other tendons can be much more readily determined. Philips¹¹ has described a lateral position for the clavicle which is useful in determining more exactly the position of displaced fragments.

While much has been written on roentgen pelvimetry, the simplest method of recent years is that described by Ball and Marchbanks¹² utilizing a device for the mathematical correction of the errors present in the usual roentgenogram. Stereoroentgenography, as described by Hodges and Ledoux,¹³ is more complex but is also of considerable value. Moloy¹⁴ using stereoscopy also advances a simpler procedure.

Numerous studies of the technic of exposure in postoperative chest conditions have been made. The problem of obtaining readable films of the normal lung while penetrating sufficiently the surgically collapsed or heavily infiltrated abnormal lung has been solved in a number of ways. Obviously the simplest procedure is to make two roentgenograms, one with the usual chest technic, the other with much greater than normal exposure, with or without the use of a Bucky diaphragm. Determan¹⁵ advocates the use of a filter blocking out part of the radiation on the side of the normal lung. Sampson¹⁶ uses a lead protector, exposing half the film only for the normal side; this is followed by a Bucky diaphragm exposure of the abnormal side on the unexposed half of the film. An opaque plastic covering the normal side of the chest is suggested by Gershon-Cohen;¹⁷ by this means, radiation through the normal lung is reduced.

Soft tissue radiography for the demonstration of soft tissue tumors, inflammatory changes, vascular abnormalities has been developed particularly by Carty.¹⁸ Further studies of technic in radiography of the breast have been made by Lockwood¹⁹ and Fray and Warren.²⁰ The latter emphasize the value of stereoscopic films.

Changes in the methods of gastrointestinal examination have been characterized by the increased use of the so-called mucosal technic. In this is embodied the use of small amounts of barium mixture, the application of pressure to the area of involvement, and the making of roentgenograms under fluoroscopic guidance. The utilization of various types of barium meals and their effects is well brought out by the studies of Ravdin and others.²¹ In general a barium water mixture is being adopted. This is, no doubt, the most effective meal for examination of the small intestine, to which attention has been recently directed. In the examination of the colon, the double contrast enema²² and the use of colloidal substances for demonstration of the mucosa²³ are not new but have been more widely adopted.

The technic of cholecystography has been modified largely by the introduction of the divided dose method of administering the dye²⁴

phragm. In dealing with seriously ill patients, these afford a means of making roentgenograms with the grid without removing the patient from the litter upon which he was transported to the x-ray department.

Fluoroscopic units have been greatly improved, first, by making them shockproof, second, by increasing the illumination produced on the fluoroscopic screen, and last, by the production of a practical device for "spot-film" work. By the latter means, roentgenograms can be quickly made during the course of fluoroscopy in order to record findings fleetingly or imperfectly observed under the screen. This is of substantial value in the diagnosis of diseases of the gastrointestinal tract, in bronchography and in myelography.

Kymographic apparatus has just been made generally available in this country. While the practical value of this equipment may still be debated, it no doubt adds something to the armamentarium of the roentgen diagnostician. By means of this type of moving grid, a roentgenographic picture of the motion of various organs can be obtained. Perhaps it is an oversimplification to state that this equipment facilitates the permanent recording of the motion which can be so readily seen by fluoroscopy. As such it is particularly applicable to the study of the heart, the ribs, diaphragms, lungs, esophagus, gastrointestinal tract, and kidney pelvis. The advantages of this apparatus in diagnosis of the surgical diseases of the thorax have already been well established. The general aspects of this type of roentgenographic technic have been thoroughly described by Stumpf.¹

An extremely complicated piece of machinery is being used abroad for planigraphy or tomography.²⁻⁵ By means of this apparatus it is possible to make roentgenograms of organs in any plane, the selected plane appearing reasonably sharp and distinct, while all the structures anterior and posterior to it appear to be out of focus. The localization and demonstration of deep-seated cavities in the lung, for example, can thus be accomplished. It is too early to state positively, however, whether this equipment will be of lasting value.

From the standpoint of technic, there have been few radical changes. Outstanding among them, from the point of view of the surgeon, are the procedures for making lateral views of the hip. Several methods have been described. George and Leonard⁶ advocate the use of a curved cassette placed within the crotch of the patient while the tube is directed from a point above and lateral to the greater trochanter. Wittek-Salzburg⁷ and Johnson⁸ use the ordinary cassette, and with a shockproof unit, the tube is placed between the thighs, the cassette on the outer surface of the hip. Particularly in cases of intra-capsular fracture, the lateral (often called vertical) projection permits greatly improved diagnosis as to the position of the fragments of the femoral neck.

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together with the addition of a carbohydrate meal or intravenous glucose (Antonucci, Sandstrom,²⁵ Stewart and Illick²⁶). This produces much more intense shadows when the oral method is used, while greatly hastening the appearance of the shadow when the dye is given intravenously.

Pirie²⁷ advocates a new method for the localization of foreign bodies in the eye. This depends upon the fact that x-rays afford a direct stimulation to the retina. A metallic foreign body will produce a density in the circle of illumination seen by the patient when his eye is exposed to an x-ray beam. Aid in the removal of metallic foreign bodies from the eye can be obtained by the use of the biplane fluoroscope.²⁸

Ghormley and Kirklin²⁹ have called attention to the importance of oblique views of the spine to demonstrate the articular processes and their joints. Intrarectal radiography for improved roentgenograms of the coccyx is described by Sabat.³⁰

Fluoroscopy at the bedside can be readily accomplished if the apparatus devised by Sgalitzer³¹ is constructed. Ledoux-Lebard and Saget³² believe it is feasible to do fluoroscopy in illuminated rooms by means of a monochromatic light for general illumination and a colored filter in the glass over the fluorescent screen. The possibility of doing fluoroscopy in the operating room is thus greatly enhanced.

The development of methods for making indirect motion pictures, i.e., reproductions of the images on a fluorescent screen, has now proceeded to the point of practicality. For the time being this is largely of importance for teaching purposes, but the potentialities for improved diagnosis cannot be overlooked.³³⁻³⁵

(Part II will appear in the next issue of SURGERY.)

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Dr. Henry Kessler, of Newark, N. J., presented three men who had upper extremity amputations of the cineplastic type which made it possible for them to return to occupations requiring the active use of both arms. The remaining muscles in the arm or forearm stumps were used to make motor loops activating levers in the artificial member opening and closing the hand. In some, it was possible to obtain pronation and supination in the forearm by straps operated from the opposite shoulder. The artificial member can be used so satisfactorily that the patient willingly wears it with pride in achieving difficult manipulations such as writing, handling papers, cards, violin bow, tying neckties, etc.

Dr. C. Leslie Mitchell, of Detroit, reviewed the subject of the clinical significance of the serum phosphatase, stating that the studies are of definite value in Paget's disease, osteitis fibrosa cystica, and osteogenic tumors but of no value in other conditions. It is interesting to note the drop in the serum phosphatase as a result of removal of the primary tumor mass, only to see it rise again with the development of metastases. Discrepancies in the phosphatase determinations and its physiologic action in various diseases were pointed out. The level of phosphatase in the blood may not necessarily be an accurate index of the amount of new bone formation or the attempt of the body to form bone, and cellular activity in the bone concomitant with the healing of fractures is not reflected in any well-defined elevation of serum phosphatase.

Dr. S. Kleinberg, of New York City, presented cases of femoral neck fractures which were treated successfully by conservative means with the added factor of early weight-bearing in plaster. After manipulation of the fracture by the Leadbetter modification of the Whitman technic, the reduction was checked by "heel-palm test," measurements of the length of limbs to demonstrate equality, and x-ray studies. A closely fitted plaster of Paris spica practically unpadded and accurately moulded over the great trochanter and iliac crest was applied from the toes of the affected side to the axillae. In from three to seven days after the fracture, the patient was placed upright on her feet for a few minutes several times a day. In ten to fourteen days, she walked in her room with abundant assistance; and from then on, the amount of activity allowed seemed to depend largely upon the physical ability of the patient. "Blow-bottles" were used to encourage hyperventilation. The plaster of Paris spica was removed at the end of two months for x-ray and then replaced by a short spica for a further four to six weeks, then a corset for one month. The statement was made that bony union was demonstrated in the x-ray taken two months after the fracture. There was more general disagreement on this point than on any other in the presentation. In the analysis of cases, the average age was sixty-four years. Bony union was obtained in twenty-two of the twenty-four cases, and the patients were walking with a cane by the end of three months.

A discussion of the intrinsic, traumatic, and extrinsic theories of the causation of torticollis was given by Dr. F. Kidner, of Detroit, which was based on an analysis of seventy-four cases under his personal supervision. Microscopic examinations were made in operative cases showing the condition to be largely local hyalinization and destruction of the striated muscle with scar tissue replacement. Hematoidin crystals also pointed to a hematoma as the causative factor. If the muscle rupture and hemorrhage involved a segment of the muscle through part of its circumference only, the torticollis deformity did not develop; but if an entire segment was involved, deformity was inevitable. If the sheath of the sternomastoid muscle is divided and closed with a deep suture after resecting a portion of the lower end of the muscle as recommended by the author, there is

Review of Recent Meetings

REVIEW OF THE FIFTH ANNUAL MEETING OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

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THE Fifth Annual Meeting of the American Academy of Orthopaedic Surgeons was held in Cleveland on January 10 to 14, 1937, with a registration of 681 surgeons marking this as the largest and most successful session. The examination sponsored by the American Board of Orthopaedic Surgery preceded the general program.

Monday, January 11, 1937, was a clinical day presented by the local men. Among the cases shown were some of congenital scoliosis in older female children accompanied by the development of complete paraplegia. Laminectomy in the affected area cleared up the compression on the cord and complete restoration of function occurred. Several cases of sciatic pain and backache due to enlargement of the transverse process of the fifth lumbar vertebra were shown. They presented atrophy of the leg, pain and limp on the affected side; all received complete relief from symptoms following removal of the enlarged process. A large giant-celled tumor of the lower third of the radius had been resected and the defect in the shaft of the bone made up for by a massive graft into the carpus. There being no recurrence of the tumor a year later, resection of a segment from the lower end of the ulna gave a very excellent range of supination and pronation of the forearm. A knee joint arthroplasty, repair of cruciate ligaments, and repair of lateral ligaments of the knee joint were shown with excellent stability and painless motion.

Music in the bones was the theme of one presentation in which the transmission of vibrations of a tuning fork or electric oscillator through osseous tissue and across joints gave information as to the state of continuity in the bone, the accuracy of reduction of a fracture, or the degree to which healing had advanced.

Tuesday, January 12, 1937: Dr. Merrill Mensor, of San Francisco, gave a paper on injuries of the accessory processes of the vertebrae and showed some excellent x-ray studies of fractures through these parts of the spine. It is difficult to differentiate congenital anomalies from fractures in the absence of a history of trauma except by repeated roentgenograms which would probably show progression toward healing in the case of fractures and no change in the case of congenital lesions. The necessity for roentgenologic studies from various angles and their accurate interpretation is of great importance in making a diagnosis. The lesion should be suspected if severe backache follows a marked torsion strain with or without flexion or extension. Failure to recognize the condition frequently leads to nonunion and persistent backache which may require surgical interference for its correction. The possibility of facet fractures accompanying any crushing injury of the vertebral body must be kept in mind and care should be taken to have a traction element acting when reduction of the spine fracture is undertaken.

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Advantages: Stability, relief of pain and fatigue, and in some cases union of the fracture of the femoral neck takes place. Complications: Delayed union in four of the twenty-eight cases reported; increase in genu valgum; loss of angle at the site of osteotomy. The use of this procedure in osteoarthritis was also mentioned, the arthritic head being removed and then an osteotomy done to relieve pain and produce stability.

Dr. E. Wolcott, of Des Moines, Ia., reported again on his work on circulation and nutrition of the head of the femur and showed radiographs of specimens injected with metallic mercury. He has traced a branch from the medial circumflex branch of the profunda femoris artery through the cotyloid notch to join with the artery of the ligamentum teres to supply blood to the epiphyseal portion of the head of the femur. The feeling was expressed that although these studies reveal that 20 to 25 per cent of femoral heads receive no blood supply through this ligament which may be a factor in the failure of fractures of the femoral neck to unite, there are undoubtedly other factors which must always be kept in mind such as important shearing stresses at the site of fracture and interposition of soft parts in fracture line. It is probable that shearing stress is the most important element to be considered.

The Colonna operation for ununited fractures of femoral neck in which there has been complete absorption of the neck was again reported by the author. He has had fifteen cases in whom he has been able to restore stability, preserve motion, relieve pain, and reduce the amount of existing shortening. This method must not be used if there is any neck left or any bony spicules on the medial side of the shaft at the base of the neck. Motion pictures were shown of the patients walking, climbing steps, abducting the thighs, etc.; and the degree of motion and stability obtained was obviously very satisfactory.

A paper was given by Dr. William Cubbins, of Chicago, on the "nailing" of fractures of the neck of the femur. He has advocated the Callahan technic using a trough or V-shaped nail inserted through an anterolateral incision through which the capsule of the hip joint can be opened for inspection of the fracture site. Motion pictures visualized the technic used.

Dr. C. B. Higgins, Milton, Mass., presented his interesting work on the effect of temperature changes on the distribution of red and yellow bone marrow in the skeleton and mentioned the reticulocytes in the red marrow as perhaps having something to do with the plan of distribution of secondary malignant deposits in the bone.

A symposium on fractures of the ankle was presented by Dr. Sumner Roberts, of Boston; Dr. Robert Schrock, of Omaha; Dr. William Darrach, of New York City; and Dr. J. S. Speed, of Memphis, Tenn. The etiology and classification, the treatment of severe fractures, operative methods in treatment of severe fractures and the treatment of malunited and disabling ankle joint fractures were taken up. There was no especially new information brought out except that in the treatment of severe comminuted ankle joint fractures involving more than one-third of the tibial joint surface and in the bad T- and Y-fractures, it was recommended that an ankle joint fusion be performed. There was definite dissension on this point as being a little too radical. Prolonged fixation after early accurate reduction seemed safer and productive of good results in the hands of a number; whereas, others recommended fusion if there was any question of painful function being the end-result.

no need for any postoperative fixation. Kidner has had only one recurrence in nineteen years and that was in a patient who did not remain under treatment following operation.

Great interest was shown in the shoulder seminar conducted by Dr. E. A. Codman, of Boston. Men who have done outstanding work in the study and treatment of shoulder joint lesions had been invited by the chairman to present various phases of the question. Muscle transplantation for circumflex nerve paralysis was discussed by Dr. Frank Ober, of Boston. Forty-one cases upon whom fifty-four operations had been done were used for this analysis. The operation consists essentially in the transplantation of the long head of the triceps and short head of the biceps to the acromion of the scapula with the shoulder held in abduction. The best results were obtained in those children whose muscles were normal except for the loss of the deltoid power. Definite improvement in stability and function was obtained in most cases. In eighteen of the children, normal stability was obtained.

Dr. R. Patterson, of New York City, told how salt solution injection in painful shoulders has brought dramatic relief in acute painful lesions. A detailed description of the technic used in lavage of the subacromial bursa with salt solution was given. Material obtained was thick and creamy like "tooth paste." In most cases, pain was gone after the first syringe full of saline solution. Total quantity used was about two ounces. Temporary use of a sling for partial support with complete function in the arm after four to six days was the usual history. This technic promises to cut down the prolonged painful disability in acute subacromial bursitis.

Whether the rupture of the long head of the biceps brachii is due to trauma, wear and tear, or attrition of old age was discussed by Dr. E. Gilcreest, of San Francisco; and in spite of many excellent slides showing the pathologic condition at operation, methods of repair and restoration of function, it is quite apparent that there is not as yet any general agreement on the etiologic factors responsible for the condition.

Four recent acute cases of rupture of the supraspinatus tendon were presented by Dr. Leo Mayer, of New York City. All had been treated by operation at which the pathology was easily demonstrated. Some difficulty is encountered in exposing the retracted proximal end of the tendon and in fastening it securely to its anatomic insertion. Motion in the shoulder should not be started in less than four weeks and one should not expect to get full return of power in the muscle, although there need not be any functional loss in the shoulder. Excellent colored moving pictures of the lesion and operation for its repair were shown by Dr. D. M. Bosworth, also of New York City.

Wednesday, January 13, began with a paper on the Schanz osteotomy for femoral neck fractures by Dr. Herman Schumm, of Milwaukee. The indications for this procedure in the hands of the author were definite nonunion or fibrous union with coxa vara. The difference between high Schanz and low Schanz osteotomies and the Riedel modification of the technic were mentioned and the author's preference for the latter stated. Greater stability and improved efficiency of the gluteal muscles is obtained as a result of improving the lever action of the upper end of the femur. If there is a genu valgum present prior to operation, this is likely to increase and become a factor in the production of pain later on.

formed operation, removal of the entire coccyx by sharp dissection, beveling the lower end of the sacrum, and closure of the deep pelvic floor should give satisfactory result with complete relief of pain.

The Mechanics of the Lumbosacral and Sacroiliac Joints were discussed by Dr. L. T. Brown, of Boston.

Nerve Root Pain Due to Intraspinal Protrusion of the Intervertebral Disk was presented by Dr. J. G. Lovè, of Rochester, Minn. Diagnosis of the lesion is made in cases of intractable back pain, which do not yield to the customary measures, by lumbar puncture to determine total protein content of the spinal fluid. If this is elevated, lipiodol injection reveals a filling defect at the site of the lesion. Reverse Queckenstedt test shows marked increase in the pain referred on the affected side. Laminectomy with removal of the protruded disk has led to relief.

The final paper concerned with The Compensation Aspects of Low Back Conditions was presented by Dr. H. L. Prince, of Rochester, N. Y. A plea was made not to frighten the patient into believing that his condition was a very serious one. Acute back sprains should be treated with adhesive plaster, a few days' complete rest, and relaxation in bed using narcotics if necessary, followed by early active exercises and return to work. The common use of plaster of Paris and mechanical brace support can be quite dangerous to the mental attitude of the individual as well as prolong the period of disability.

Thursday, January 14, 1937: **Anthroplasty of the Hip Joint. End-Result Study of Seventy-Nine Unselected Cases** by Dr. Hulford Hullock, New York City, was first presented.

This was a study of seventy-nine cases treated in one hospital by various surgeons and various technics from 1919 to 1934. The etiologic factors responsible for the ankylosis requiring arthroplasty included osteoarthritis, septic arthritis, coxa vara, slipped femoral epiphysis, etc. The results were very poor as mobility was unaffected or lowered in 71 per cent of the cases. Most cases had painful hips after operation although stability was good. Since 1934, technical improvements have increased the so-called good results although pronounced pain and limp often persist after operation.

Dr. B. Moore, of Chicago, presented a paper on **Effect of the Periosteum on the Position of Fracture Fragments**, in which he showed that the periosteum has a definite mechanic effect in assisting or impeding the reduction and retention of the fragments of a fracture. He made a plea for gentler manipulations of fractures and an understanding of what the torn or stripped periosteum may be expected to do in helping or hindering the reduction.

Three papers on tuberculosis of bones and joints were read. The first by **Dr. A. B. Ferguson**, of New York City, dealt with the soft tissue shadows of the joints and the information one can obtain regarding effusion, atrophy, infiltration, chronicity of the lesion, and so on. Aided by the clinical history, it is possible to make a diagnosis of tuberculosis of a joint even before osseous changes are apparent. **Primary and Secondary Osseous Lesions in Tuberculous Arthritis** was presented by **Dr. C. H. Hatcher**, Chicago. He stated that tuberculous involvement of the joints is usually another manifestation of a primary lesion elsewhere in the body. The location of the lesion may be in the bone or synovia. The lesions in children are rarely found in the epiphysis; whereas, they are more usual in the epiphysis in adults. Some excellent colored photomicrographs added much to the value of the paper. The case for **Tuberculosis of the Spine in Children** was again stated by **Dr. E. F. Cave**, of Boston. One hundred twenty-two cases have been treated in the past seventeen years. Diagnosis was made on history, clinical, x-ray, serologic, and laboratory findings. Sixty per cent of cases showed positive pulmonary changes and 75 per cent of cases develop tuberculous abscesses. Mortality of 17 per cent was reported, most of which was due to development of amyloidosis. Fusion in twenty-two cases was done after the disease was quiescent as a means of preventing deformity and recurrence.

A symposium on **Low Back Lesions** with **Dr. Joel E. Goldthwait**, Boston, as chairman occupied the entire afternoon of the last day of the meeting. **Dr. Theodore H. Willis**, of Cleveland, spoke on the **Anatomical Structure of the Lumbar Region Including Variations**. Many of the common variations found in 27 per cent of cases were mentioned. Backache due to enlarged transverse processes was frequently relieved by postural treatment which was designed to correct mechanical strains placed on the anomalies at the lumbosacral junction. **Dr. E. L. Compere**, of Chicago, followed with the **Operative Treatment**, presenting tables showing indications for various forms of surgical procedures and the results obtained.

Sacrococcygeal Lesions were discussed by **Dr. J. Albert Key**, of St. Louis, with special mention of the chronic type of coccygodynia. Operative removal of the coccyx is definitely indicated if chronic disability is produced. A carefully per-

as described by Burgess, would give a foundation to the student and practitioner in studying the excellent chapters dealing with the bony pelvic abnormalities.

Unquestionably, the book remains substantial among obstetric texts and should be accorded a prominent place in the library of the practitioner and student.

Medical Morals and Manners. By H. A. Royster. Cloth. Price \$2.50. Pp. 333. Chapel Hill, N. C., 1937, The University of North Carolina Press.

The American student of medicine of our day has become familiar with the charm of philosophic medical essays in monographic form largely through the delightful *Aequinimitas* of the late William Osler and the equally refreshing *Consecratio Medici* of Harvey Cushing. A fairly large number of monographs of this type have come from the pens of distinguished English and American men of medicine and surgery. In a manner, such essays may be said to be in part autobiographical in character, for they reveal the interests and outlook of the author in many reflective moods.

Such, too, is the subject matter of this text in which a well-known American surgeon discourses upon a variety of topics. There are in all thirty-one essays, listed under five headings. The majority of the papers are addresses which have been delivered before medical audiences; some are semipopular in nature. This collection of philosophic essays interestingly written by a thoughtful surgical idealist, given to meanderings into nonmedical literature and possessed of a well-developed historical sense, should find favor with students of surgery.

Lectures on Embolism and Other Surgical Subjects. By Gunnar Nyström. Cloth. Price \$3. Pp. 213, with 66 illustrations. Baltimore, 1936, Waverly Press, Inc.

This small volume of five chapters relates to lectures given by the author as Abraham Flexner Lecturer at Vanderbilt University. A note on the Abraham Flexner Lectureship by Chancellor James H. Kirkland and a foreword by Barney Brooks introduce the monograph to American readers. The name of Gunnar Nyström, professor of surgery at the University of Uppsala, Sweden, has become well known to American surgeons in the last decade through his surgical successes with pulmonary embolectomy. The problem of pulmonary embolism and embolism of the arteries of the extremities and their surgical treatment are well discussed. Equally interesting to American surgeons is the informative chapter on the treatment of fractures of the anatomic neck of the femur. Smith-Peterson's method of dealing with these fractures together with Sven Johansson's modification which are widely practiced in Sweden are well illustrated and described. The remaining two chapters deal with the problem of appendicitis in Sweden and the cytology of joint exudates. The author inclines to the belief that all instances of acute appendicitis, no matter what the extent of the disease, should be treated surgically—a thesis which is rapidly losing ground in the United States.

This volume can be enthusiastically recommended to all practitioners of medicine who have an interest in the subject matter.

The Law of Drugs and Druggists. By William R. Arthur. Cloth. Pp. 487. St. Paul, 1936, West Publishing Company. \$3.

The author, who for several years has been giving the short course on drug law to the senior classes in the School of Pharmacy at the University of Colorado, carries on the work in this volume that was commenced many years ago by Dean Washburn, of the School of Pharmacy, and himself.

Book Reviews

Williams' Obstetrics: A Textbook For the Use of Students and Practitioners,
Edited by Henrius J. Stander, Cloth Pp. 1269, with 729 illustrations. New
York, 1936, D. Appleton-Century Company, Inc.

When the author of this revision states in his preface, "an attempt has been made to retain as much of Dr. Williams' last revision as is consistent with the new developments in obstetrics," the reader is prepared for a continuation of the conservative dignity of the previous Williams' revisions. In the rewritten chapters, little can be found that departs from the high standard of obstetric literature set by the late Dr. Williams.

Three new chapters are found in the book. The first of importance from the standpoint of the practitioner is the chapter dealing with the hormones as related to menstruation, pregnancy, parturition, and lactation. Here is a precise, understandable summation of a subject around which a voluminous incomprehensible literature has accumulated. To the practitioner interested in undertaking endocrine therapy, this addition should be of value in serving as a basis from which excursions may be made into more complex reading. Another new chapter, second in interest if not in importance, is the chapter dealing with obstetric anesthesia and analgesia. All of the common, newer methods are detailed. Here again, a sizable literature, which while not as incomprehensible as in the case of the hormones, but yet somewhat confused by personal enthusiasms is epitomized into a workable understanding. The free use of morphia described in the routine analgesia of the New York Lying-In Hospital is a surprise, in view of the general exclusion of this drug during labor in most places. The third new chapter and the one which probably will be read the least, because of the lack of exploitation of the subject, is the one dealing with diseases of the kidneys and urinary tract. Here is found a concise description of the physiology of the urinary tract during pregnancy, an understanding of which is fundamental to clinical obstetrics, and which, while an old subject, has had a recent revival of interest among urologists.

In the section of the book dealing with the physiology of pregnancy, the chapters concerned with the "changes in the maternal organism resulting from pregnancy" and the "management of normal pregnancy," could be more effective if combined or placed adjacently. For what is the management of normal pregnancy if it is not the close observation and attempted regulation of the maternal physiologic changes resulting from pregnancy? Obstetric consultation practice reveals that lack of even reasonable antepartum care is one of the faults in American obstetrics today. Certain formal "prenatal" examinations and recommendations are made, but many times without intelligent interpretation of the results. Consequently, any emphasis of the antepartum phase of the subject of obstetrics would seem desirable.

Pelvimetry is described in the section of the book dealing with the pathology of labor in the chapter concerned with contracted pelvis. This placing of the subject causes some loss of accentuation on the use of pelvimetry as a routine procedure. Pelvimetry as a function has reached new proportions with the development of radiographic techniques and could properly be accorded the dignity of a chapter, which, with the inclusion of some simple pelvic classification such

as described by Burgess, would give a foundation to the student and practitioner in studying the excellent chapters dealing with the bony pelvic abnormalities.

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This book is ideal for physicians, pharmacists, and nurses who desire to know something of the legal aspects of the medical profession, and for those who wish information concerning the relationship of law in the practice of medicine in so far as the dispensing of drugs is concerned.

Part I covers state and local laws and is of special value to pharmacists. Part II covers the subject of federal statutes and relations. One chapter covers the subject of the Harrison Anti-Narcotic Act. Actual court cases are cited. Many points are made clear for the guidance of the prescribers and dispensers of drugs.

The aim has been to cover in a concise and practical manner the area wherein law and the prescribing and dispensing of drugs overlap. For the benefit of the physician and pharmacist, the legal terminology could have been much reduced and technical terms could have been simplified in an effort toward clarity as well as accuracy.

A doctor once said: "If a man knows what malpractice is, he can almost avoid it. In other words, the more law he knows, the more he can be kept out of court or at least the terrors of it."

This book can be well recommended, especially to the students of pharmacy.

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Original Communications

SIMPLE ULCER OF THE ASCENDING COLON AND ITS COMPLICATIONS

SIR DAVID WILKIE, M.D., EDINBURGH, SCOTLAND
(*From the University of Edinburgh*)

IN mammals no part of the alimentary tract presents greater variation in size and functional activity than the proximal part of the colon. In the herbivora it is large and capacious to accommodate and to permit of the final digestion of the bulky vegetable diet. In the carnivora it is relatively small and unimportant and its removal causes little upset of digestion. Man, primarily herbivorous, has become facultatively carnivorous, and his proximal colon is thus placed in that awkward state of unstable equilibrium which renders it susceptible to trouble.

Apart from the vermiform appendix, the common site of trouble is in the ascending colon, some little distance above the ileocecal valve. Sir Arthur Keith pointed out that in many of the lower animals, particularly in birds and rodents, there is a sphincter mechanism in the proximal colon which prevents too rapid emptying of this part and allows of the completion of digestion. Keith gave the name cecocolic sphincteric tract to this usually contracted area of the proximal colon, and the portion proximal to it and distal to the ileocecal valve he called the cecal colon (Fig. 1). No such sphincteric tract exists in man, but very frequently we find spasm in the ascending colon in the corresponding area, and it is the common site of malignant disease in the proximal colon.

If we regard the proximal colon as a second stomach, the ileum represents the esophagus; the cecum, the cardia; the cecal colon, the body of the stomach; and the cecocolic tract, the pyloric antrum and pylorus. In the stomach the pyloric end is the common site of carcinoma but the lesser curvature that of simple ulcer, so in the proxi-

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mal colon carcinoma is found in the region of the cecocolic tract, simple ulcer on the lesser curve; i.e., the medial wall above and beyond the ileocecal valve. (Fig. 2.)

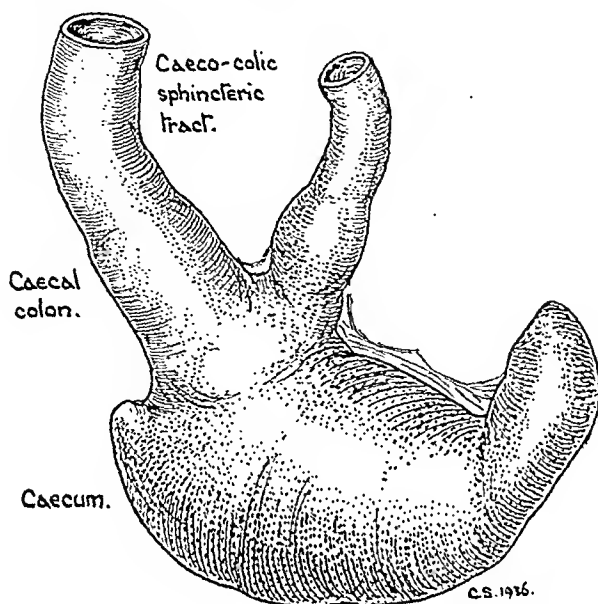
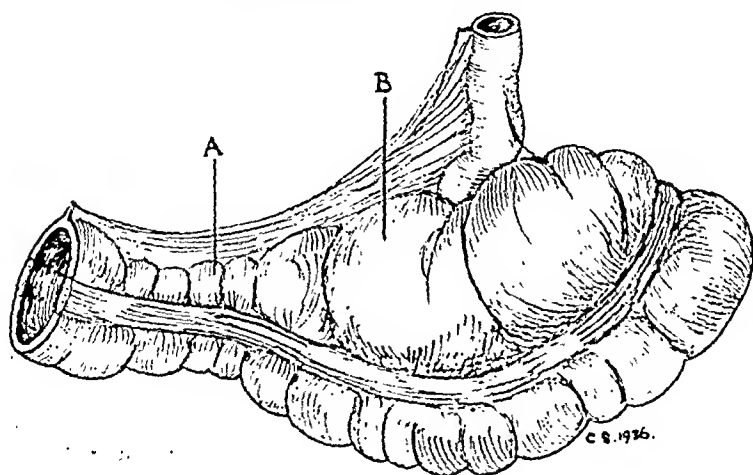


Fig. 1.—Ileum and proximal colon of rat. The contracted cecocolic area appears to have sphincteric function.



A. Common site of Cancer.

B. Common site of Ulcer.

Fig. 2.—Human proximal colon. If regarded as a second stomach, it is seen that the sites for ulcer and stenosing carcinoma correspond to those of the true stomach. The cecum, like the gastric fundus, is commonly the seat of fungating carcinoma.

In this communication, four examples of that reputedly rare condition, simple ulcer of the ascending colon, are recorded. Strangely

enough, they illustrate almost all the various clinical features which may characterize such ulceration and also the complications to which it may give rise. These four cases were met with over a period of more than twenty years' practice in abdominal surgery. This might suggest that the condition is a very rare one. I am inclined to think, however, that minor degrees of such ulceration may be relatively common and that even at operation the condition may be overlooked.

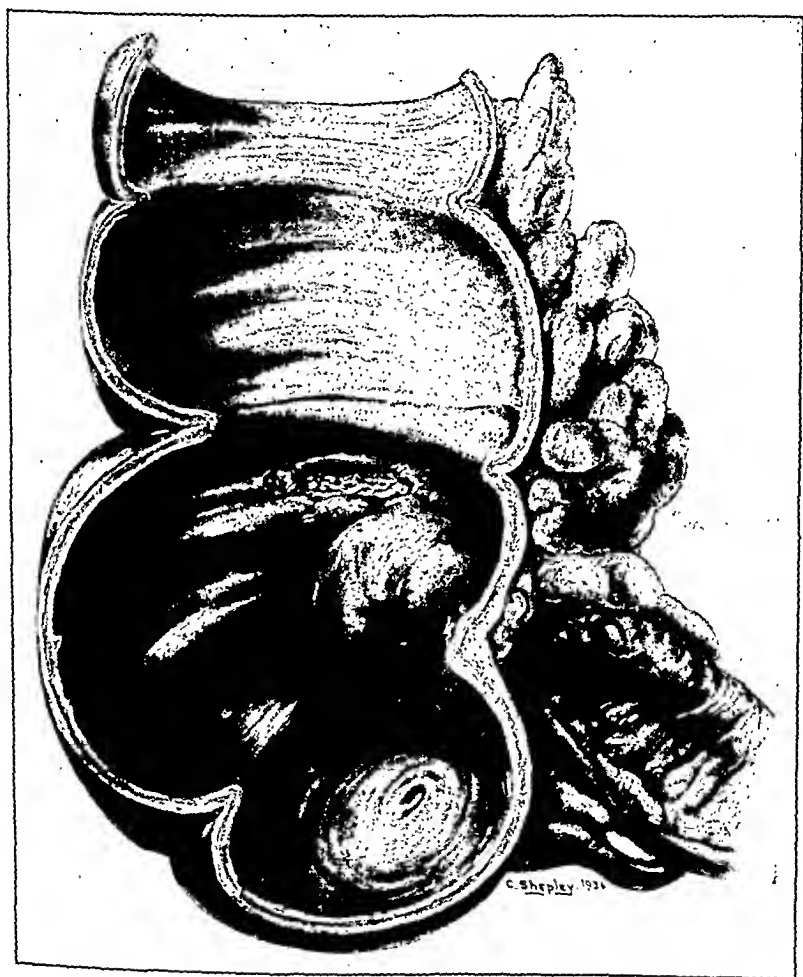


Fig. 3.—Simple ulcer of cecal colon simulating carcinoma. Note common situation above ileocecal valve.

SIMPLE ULCER SIMULATING TUMOR

CASE 1.—Male, aged forty-five years. *Complaint.*—Pain in the abdomen and passage of blood from rectum.

Apart from chronic constipation, the patient had been in good health until three weeks before his admission to hospital. At that time he began to suffer from slight pain in the right lower quadrant of the abdomen, and on one occasion he passed about one ounce of red blood per rectum. He consulted a doctor who, on examining

the abdomen, discovered a swelling in the right iliac region and sent the patient to a hospital with the diagnosis of chronic appendicitis.

On examination he looked a healthy man; the abdomen was not distended; on palpation, a swelling ill-defined, about one and a half inches in diameter, could be felt in the right iliac fossa. This was not tender to touch, was mobile, and was taken to be inflammatory thickening, in all probability associated with chronic appendicitis. No radiologic examination was made.

Operation.—The abdomen was opened through a gridiron incision in the right iliac region. On pulling out the cecum a firm swelling was felt at, and just above, the ileocecal valve. The appendix was normal. From the densely hard character



Fig. 4.—Proximal colon in Case 2, seen from behind, showing extraperitoneal perforation.

of the swelling in the ascending colon, the diagnosis of carcinoma was made and the proximal part of the colon resected. The ends of the ileum and colon were closed and a lateral anastomosis performed. There was little evidence of glandular involvement and no sign of tubercle either in the small intestine or mesenteric glands. The patient made an uneventful recovery.

On opening the specimen removed, there was seen to be a punched out ulcer, closely resembling a gastric ulcer, and situated on the medial wall of the ascending colon just above the ileocecal valve (Fig. 3). The margins of the latter were pouting and edematous, the mucous membrane of the cecum and the rest of the ascending colon appeared normal. Outside the base of the ulcer there was considerable induration in the ascending mesocolon.

A wedge was taken from the ulcer for microscopic section. The latter showed marked small celled infiltration of the tissue around the ulcer but no evidence of malignant disease or of tubercle.

Summary.—Simple ulcer of the ascending colon simulating malignant disease. Resection of proximal colon. Recovery.

RETROPERITONEAL PERFORATION OF SIMPLE ULCER CAUSING PSEUDOHERNIA

CASE 2.—Mrs. F., aged sixty-four years. The patient had always been a delicate woman and had suffered from chronic constipation. For some months she had been getting noticeably thinner, and one month before began to complain of pain on the

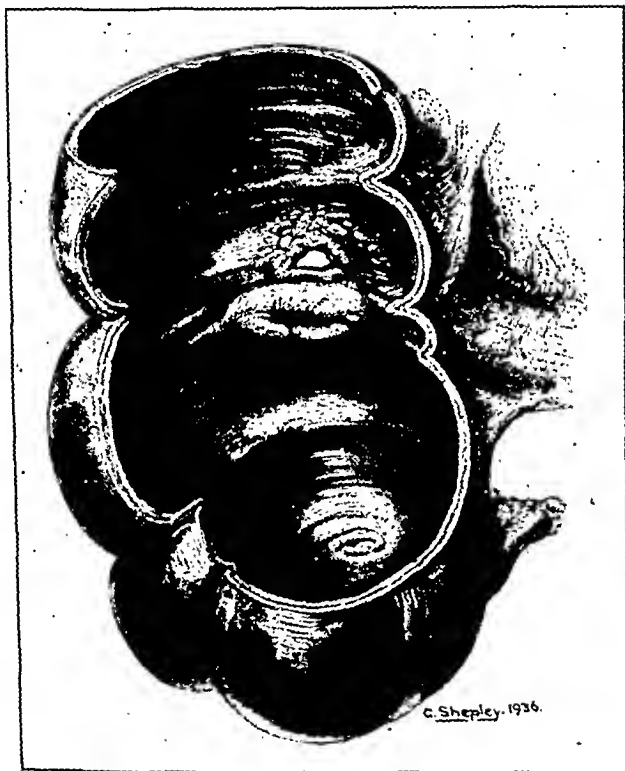


Fig. 5.—Case 2. Showing perforation from mucous aspect. Note typical situation.

right side of the abdomen. When examined by her doctor at this time, an indefinite tender swelling could be made out in the right lumbar and iliac regions. While she was under observation her doctor noted the gradual development of a visible swelling in the right iliac region, situated one inch internal to the anterior superior spine. The swelling was soft and yielding; it varied greatly in size from time to time and when pressed on would disappear slowly to reappear again. It suggested a hernia but was some distance from any of the usual hernial apertures. The patient continued to become thinner and weaker, and the constipation became more obstinate.

On examination on August 4, 1919, she was seen to be a very pale, emaciated, and weak woman; the abdomen was not distended. In the right iliac region there was a visible swelling, the size of a hen's egg, situated as above described. On palpation there was no tenderness, and the swelling readily disappeared within the

the abdomen, discovered a swelling in the right iliac region and sent the patient to a hospital with the diagnosis of chronic appendicitis.

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SIMPLE ULCER LEADING TO STENOSIS WITH CECAL DISTENTION
AND STASIS

CASE 4.—Mrs. K., aged forty-nine years, had for ten years suffered from flatulent distention and dragging pains on the right side of the abdomen. For the past three years she had complained of periodic attacks of indigestion of the hunger type and had received medical treatment for indigestion.

X-ray examination showed a definite deformity of the duodenal cap, strongly suggestive of ulcer. The striking feature in the x-ray examination, however, was the prolonged stasis in the cecum, which retained a considerable residuum of barium long after most of the meal had passed through the colon.

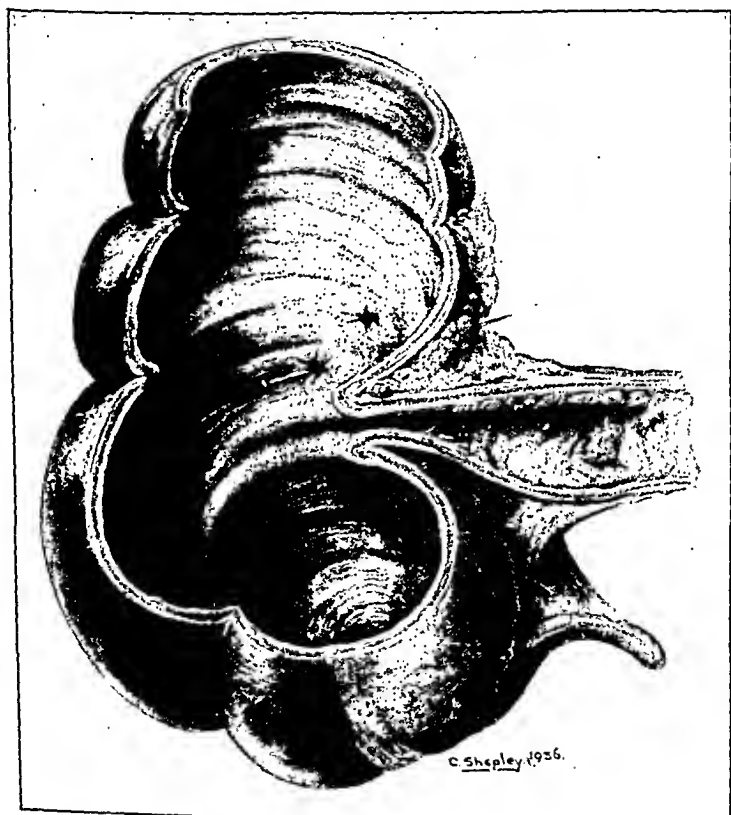


Fig. 6.—Case 3. Perforation of simple ulcer into peritoneal cavity. Note second ulcer above perforated one and scars of two healed ulcers in ileum.

The patient, who had been for some years resident in India, gave a history of several attacks of diarrhea some years before. These were considered not to be true dysentery, and for the past two years she had been quite free of them.

The provisional diagnosis before operation was "duodenal ulcer and simple stenosis of ascending colon."

Operation.—On July 4, 1928, the abdomen was explored through a right rectus incision. A very definite duodenal ulcer was found on the anterior wall of the duodenum. The second part of the duodenum was mobilized and a gastroduodenostomy performed.

abdomen when pressed on. It was tympanitic on percussion and obviously contained gas. A slight fullness could be felt in the right lumbar region posteriorly.

A diagnosis was made of free gas in the extraperitoneal tissues, in all probability due to a leak through a growth in the region of the cecum or ascending colon. An operation was advised but was at this time refused. Two days later the patient became much worse and was sent into a nursing home. By this time the swelling in the right iliac region was much larger, the skin over it was purplish in color and on the point of becoming necrotic.

Operation.—An incision was made into the swelling which, on being opened, collapsed with the escape of gas. The cavity communicated through a relatively small aperture in the abdominal wall with a much larger cavity which extended from the right kidney above down to the floor of the pelvis. This cavity, which was extraperitoneal, was lined by a gray, sloughy membrane and contained nothing but gas. Owing to the patient's critical condition all that was done was to insert Carrel's tubes and to irrigate with eusol. The patient died the following day.

Postmortem.—On opening the abdomen there was seen to be no peritonitis and no evidence of tumor growth in the colon. The peritoneum of the posterior abdominal wall on the right side had been dissected up by gas, and on reflecting it forward the very large cavity which had been found on operation was examined. A small perforation, 5 mm. in diameter, was found on the posterior aspect of the ascending colon, three-quarters of an inch above the ileocecal valve. (Fig. 4.) On opening the colon an elongated ulcer was found on the posteromedial aspect of the ascending colon, which had perforated into the retroperitoneal cellular tissue. (Fig. 5.) There was no ulceration in any other part of the bowel and no signs of tubercle or carcinoma. The colon was not unusually dilated, and there was no obstruction to its lumen at any point.

Microscopic sections of the ulcer showed merely the inflammatory reaction associated with a so-called simple ulcer.

Summary.—Simple ulcer of ascending colon. Perforation into retroperitoneal tissue. Formation of gas-filled pseudohernia. Death from toxemia.

INTRAPERITONEAL PERFORATION OF SIMPLE ULCER

CASE 3.—Female, aged fifty-six years. Admitted to a medical ward of the hospital, suffering from abdominal pain and distention, in a very collapsed condition.

History.—The patient had suffered from chronic constipation, but some eight days or so before admission she began to have diarrhea which continued until admission. Three days before admission she was seized with very severe pain in the right side of the abdomen. This continued and spread all over and was accompanied by vomiting and great prostration.

On examination the patient was collapsed and unable to answer questions, pulse thready, 140, abdomen distended and tender all over. Patient never rallied sufficiently for any surgical interference to be possible and died twelve hours after admission.

Postmortem.—Generalized feculent peritonitis. A small perforation was seen on the medial surface of the ascending colon, just above the ileocecal valve. On opening the gut, two small ulcers were found in the ascending colon, the lower of which had perforated into the general peritoneal cavity. (Fig. 6.) In the lower end of the ileum there were two irregular, scarred areas which appeared to be healed ulcers. Cultures for typhoid bacillus were negative. Sections of the ulcers showed infiltration of tissues by inflammatory cell; no evidence of tubercle.

Summary.—Simple ulcers of the ascending colon. Perforation of one causing death from generalized peritonitis.

SIMPLE ULCER LEADING TO STENOSIS WITH CECAL DISTENTION
AND STASIS

CASE 4.—Mrs. K., aged forty-nine years, had for ten years suffered from flatulent distention and dragging pains on the right side of the abdomen. For the past three years she had complained of periodic attacks of indigestion of the hunger type and had received medical treatment for indigestion.

X-ray examination showed a definite deformity of the duodenal cap, strongly suggestive of ulcer. The striking feature in the x-ray examination, however, was the prolonged stasis in the cecum, which retained a considerable residuum of barium long after most of the meal had passed through the colon.

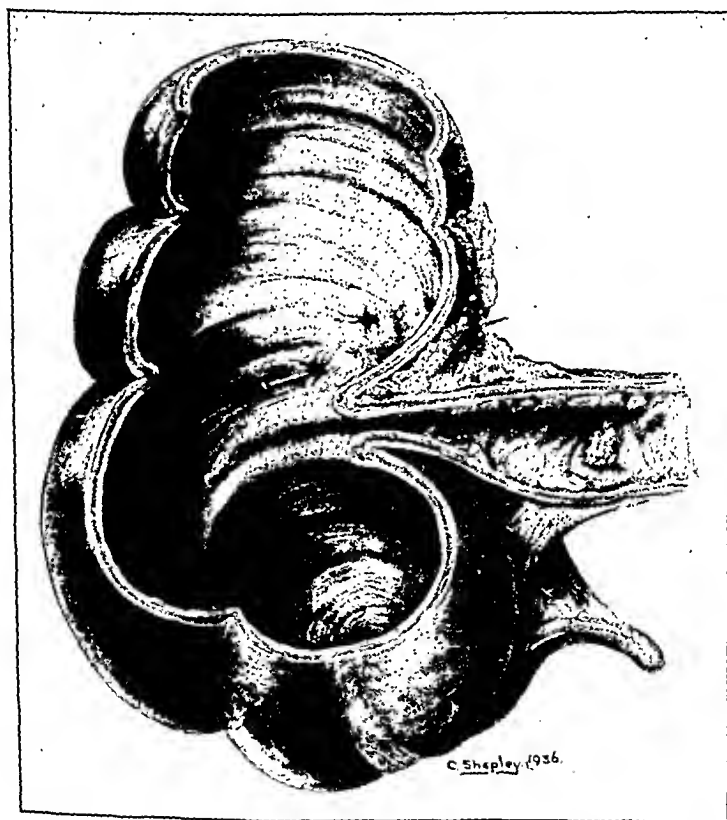


FIG. 6.—Case 3. Perforation of simple ulcer into peritoneal cavity. Note second ulcer above perforated one and scars of two healed ulcers in ileum.

The patient, who had been for some years resident in India, gave a history of several attacks of diarrhea some years before. These were considered not to be true dysentery, and for the past two years she had been quite free of them.

The provisional diagnosis before operation was "duodenal ulcer and simple stenosis of ascending colon."

Operation.—On July 4, 1928, the abdomen was explored through a right rectus incision. A very definite duodenal ulcer was found on the anterior wall of the duodenum. The second part of the duodenum was mobilized and a gastroduodenostomy performed.

The cecum was large and its wall was hypertrophied. Just above the ileocecal valve a dense band of adhesions crossed the ascending colon which, at this point, was puckered and fibrosed. (Fig. 7.) On dividing these adhesions, a fibrosed stellate scar marked the site of a healed ulcer, situated half an inch above and slightly in

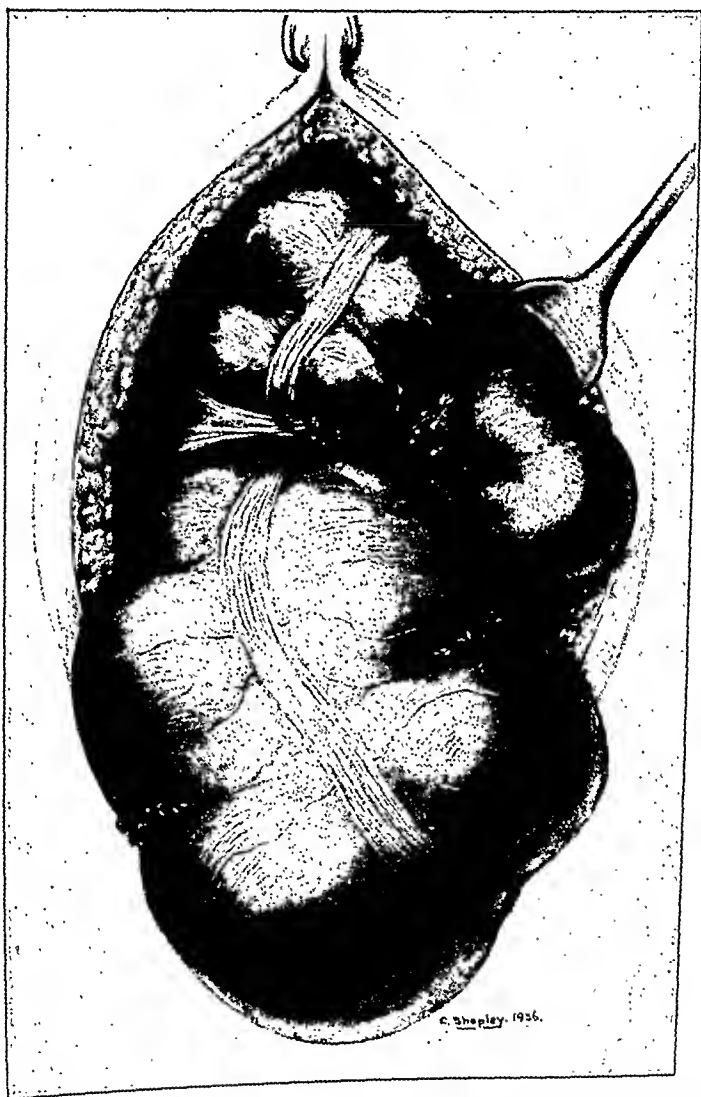


Fig. 7.—Case 4. Stenosis of ascending colon from dense adhesions to the fibrosed scar of a healed ulcer of cecal colon. Note cecal distention which was relieved by division of band.

front of the ileocecal valve. The division of the adhesions allowed of sufficient expansion of the colon to give free drainage to the cecum.

The result of the operation was most satisfactory, for not only was the indigestion entirely relieved, but the flatulent distention and discomfort in the cecal region disappeared.

Etiology.—From a study of the few previously recorded cases and the four described above, the only common factor discovered was a history of chronic constipation. It would appear that fecal stasis and fermentation in subjects past middle life may tend to lead to the development of one or more ulcers in that part of the bowel named by Keith the cecal colon. It is difficult to account for the frequency of the ulceration in the ascending colon just above the ileocecal valve as the blood supply of this segment is good. Possibly the relative fixity of the mucosa in this, the least expansible portion of the ascending colon, may have something to do with the development of a chronic ulcer in this situation which is in this respect comparable to the lesser curvature of the stomach.

Symptomatology.—Simple ulceration in the proximal colon may exist with no appreciable symptoms until some complication such as hemorrhage or acute or subacute perforation sets in. Chronic constipation is so common without ulceration that this symptom in itself is of little value, but the presence of a palpable lump or the onset of acute symptoms suggesting a perforation, in a patient the subject of chronic constipation, should suggest the possibility of this among other conditions.

COMPLICATIONS

Hemorrhage is a rare complication. In Case 1, recorded above, it was noted but was not severe. I can find no note of it in any of the other recorded cases.

Subacute perforation with pericolicitis leading to the formation of a palpable mass or the development of an abscess has been observed in several cases. The diagnosis from a neoplasm, ileocecal tuberculosis, or chronic appendicitis must ever be a matter of considerable difficulty in this class of case. Possibly some cases of perinephric abscess of obscure origin are, in reality, examples of subacute perforation of a simple ulcer of the colon into the retroperitoneal tissues.

Formation of Pseudoneoplasm of Colon.—The inflammatory thickening in and around the colon at the site of the ulcer may give physical characters almost indistinguishable from those of a neoplasm. This was well exemplified in Case 1 recorded above and in one recorded by Morel and Secheyron. In both, a resection of the proximal colon was performed with success and the benign nature of the mass only subsequently discovered.

Acute perforation is the most dangerous and, so far as records show, the most frequent complication. It may occur into the retroperitoneal tissue and give the curious clinical picture of pseudohernia met with in Case 2, or lead to a foul perirenal or subphrenic abscess. Perforation into the peritoneal cavity must always be a serious complication. It is not necessarily fatal as is shown by the successful results re-

corded by Quénn and Duval, and by Zickler after operation for closure of the perforation. Whether a simple ulcer may be the starting point of malignant disease in this region is uncertain.

Stenosis From Cicatricial Contraction.—It is not uncommon to find bands of inflammatory adhesions in the region of the ascending colon. That some of them may be the result of antecedent simple ulceration is, I think, more than likely, but I do not recall having met with another case in which the evidence of this sequence was clear and unequivocal as in the case here recorded.

TREATMENT

Since the condition can never be diagnosed with certainty before operation, treatment resolves itself into that for cases where a pseudoneoplasm has developed and for those in which perforation has occurred. In the former, doubt will still exist when the colon is exposed at operation, and a resection of the proximal colon will always be the wisest course to follow where the patient's general condition allows of it. In aged or very weak patients, an ileocolostomy, which short-circuits the ulcer, may be deemed the wiser course. Where perforation into the peritoneal cavity has occurred, simple closure of the perforation with drainage has been successful in several cases. Where the perforation is large, or where the surrounding induration makes closure impracticable, stitching of the perforation to the surface, with a subsequent resection of the proximal colon, if peritonitis be outlived, is the method of choice. In the case of extraperitoneal perforation, free drainage of the infected tissues is all that can be attempted in the first instance and, should recovery ensue and a fecal fistula persist for any length of time, resection of the affected segment will be called for.

CONCLUSIONS

1. The proximal colon is, under modern dietary conditions, very commonly the site of dysfunction and disease.
2. Simple ulcer of the cecal colon is a pathologic entity.
3. Clinically, it is encountered (a) as pseudoneoplasm of the bowel; (b) when complicated by acute or subacute perforation; (c) when fibrosis associated with healing has led to a stenosis of the colon.
4. In cases of perforative peritonitis, the ascending colon should be examined after the common sites have been excluded.
5. In gas gangrene or cellulitis of the right flank, perforating ulcer of the proximal colon should be suspected.

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CONVULSIONS ASSOCIATED WITH GENERAL ANESTHESIA

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THE problem of convulsions or spasms associated with general anesthesia is one that is presenting itself with increasing frequency. Attention was not called to it until 1927, and since then most of the reports concerning it have come from England, although a few have been made in this country.¹⁻¹³ It would seem that the condition has been recognized by but few. It seems important that the subject should be presented again, as was done in 1933 by Sears,¹² in the hope that a solution may be arrived at. The problem of convulsions and spasms associated with general anesthesia has been studied to some extent from an experimental point of view.²⁰⁻²²

I am impressed with the need for a solution of the problem and for a general warning to all to keep the condition in mind, so that it may be recognized early and treatment given in order to reduce, if possible, the number of fatalities. Table I shows a mortality of 18.9 per cent in the cases already reported. My interest has been stimulated, because I recently have been asked to express an opinion as to the cause of death in certain cases in which convulsions have been associated with general anesthesia in several different states in the Middle West during the last year. Three of the reports that have been sent to me are included in the table, as well as reports of four cases observed by me and my associates in a period of years. Six other cases also have been brought to my attention. In the literature, 137 additional cases have been found. These cases all fall into the category known as convulsions associated with general anesthesia; they originally were reported as "ether convulsions." In the literature and in my own experience, there are cases in which the patient was known to have,²³ or was found later to have had, epilepsy. It may be that in some cases, as various authors have pointed out, the condition reported as "ether convulsions" was confused with epileptic seizures, heat stroke,²⁴ or muscle spasms attributable to ethyl chloride.²⁵ Usually, there should be little difficulty in recognizing the epileptic seizure,^{26, 27} as the fit begins suddenly with a violent tetanic spasm and usually subsides with a series of isolated clonic spasms, especially if the severity of the fit does not prevent the further administration of the anesthetic. At

times, the anesthetization may be begun again after the first fit is over, and the patient may be anesthetized before another one appears.

Obviously, clonus associated with general anesthesia should not be confused with convulsions associated with general anesthesia.^{26, 28-40} Clonus usually can be corrected by changing the posture of the patient. No doubt there are other effective methods of treatment; for example, in one case I administered carbon dioxide, 5 per cent, and oxygen, 95 per cent, for five minutes, and the clonus disappeared and did not return.

I have previously reported a case in which spasm of the diaphragm occurred while the patient was under general anesthesia.¹¹ The clinical picture in this case was different from that of convulsions. The bacteriologic findings of Rosenow⁴¹ in this case, which were carried out at the suggestion of Tovell,⁴¹ led to a similar investigation of cases of generalized convulsions.

The characteristic severe convulsion associated with general anesthesia, to which I wish to call attention, usually begins with twitchings in the face; it spreads to other parts of the body with increasing violence, and may continue on for hours unless treated. Woolner and Taylor,⁴² who reported four cases in 1936, said: "The patient is a child or young adult with pyrexia, usually due to some acute septic condition. The theater is overheated. Atropine has been given, and the dose may have been excessive. The patient is deeply anesthetized with ether, the pupils being dilated and inactive to light. The color is, as a rule, good, and oxygenated ether is sometimes being given. The eyelids start to twitch, then the face, and the convulsions become general. In the immediately fatal cases, after five to ten minutes of convulsions, the respiration ceases, the patient goes blue, and the heart stops; in other cases, the convulsions stop, but the patient dies later from cardiac failure; alternatively, recovery may follow the cessation of the convulsions."

The type of muscular seizure that is progressive and that is not of short duration may or may not be dangerous. The etiology may not be known, but in any event it seems to me that the important factors are: (1) the convulsions probably can be controlled by the use of barbiturates intravenously; and (2) the most dangerous cases are those in which there is profound toxemia, and, therefore, in selecting the anesthetic for such cases, it might be better to use spinal,⁴³ infiltration, or block anesthesia, a barbiturate intravenously, or avertin to produce basal anesthesia, than to use an inhalation anesthetic only. In some cases of severe convulsions, the use of sodium amytal or pentobarbital sodium might be preferred to the use of evipal sodium

or pentothal sodium because of the prolonged effect of the former, but if either evipal sodium or pentothal sodium is used and is not fully effective, it could be followed by the administration of sodium amylal or pentobarbital sodium.

Of the dangerous type of convulsions there are two, namely, those with severe symptoms and those with mild symptoms. The outcome in these cases reminds me of the outcome that can be expected in cases of tetanus, in which the prognosis is favorable if mild convulsions come on late and unfavorable if violent convulsions occur early. The convulsions associated with general anesthesia, however, are not to be confused with those of tetanus, but it is significant that the convulsions of tetanus can be controlled with the powerful barbiturates even in a fatal case and also with avertin which, so far as I know, has not been used in the treatment of convulsions associated with general anesthesia. Preoperative medication or basal anesthesia with the barbiturates or avertin might be used in cases of severe toxemia when it is necessary to use inhalation anesthetics.

The appended table reflects the value and character of the literature on the subject of convulsions associated with general anesthesia. Unfortunately, too few details are presented in the reports of cases; therefore, considerable confusion must exist in the mind of anyone who attempts to arrive at a decision in regard to the etiologic factors involved. When an overdose of a local anesthetic enters the blood stream, it may act systemically as a convulsant. When an author feels that a convulsion associated with local anesthesia is identical with the convulsion associated with general anesthesia, it only adds to the confusion that already exists.⁴⁴ I feel that convulsions which are associated with local anesthesia should not as yet be considered to be the same as those associated with general anesthesia, although we may come to consider them to be. Some authors have felt that heat of summer was a causative factor, but it will be noted that such convulsions have occurred in the spring, fall, and winter, as well as in the summer, and that many authors do not give the information as to the time of year in which this untoward reaction developed.

The thirty-three various causes or significant factors involved in the production of convulsions associated with general anesthesia which have been mentioned in the literature are: toxemia and septicemia,^{1, 19, 45-57} an excessive amount of carbon dioxide in the system,⁵⁸⁻⁶² impurities in the ether,^{47, 50, 63-68} impurities in the oxygen,⁶⁹ trauma,¹² deep anesthesia,^{1, 34, 46, 49, 63, 70-74} hypoglycemia,^{6, 16, 19, 75} method of anesthetization,⁷⁶⁻⁸⁰ instability of nervous system,^{24, 48} overdosage of atropine,⁸¹ cerebral anemia,⁸² alkalosis,^{8, 20, 83} overbreathing,²¹ idiosyncrasy,⁹ cerebral accident,⁸⁴ disturbance of calcium metabolism,^{14, 84} ketosis,⁸⁵

heat,^{42, 65, 86-88} youth,^{47, 52, 56} use of oxygen,^{34, 89} anoxemia,^{5, 90} latent tendency to fits,^{43, 91} changes in the blood,⁷³ overoxygenation,⁹¹ sex susceptibility,⁹² increased vascularity of brain cortex,^{92, 93} concentrated ether,⁶⁰ deficiency of carbon dioxide,⁸³ lightness of anesthesia,⁴³ hyperventilation,⁹⁴ anaphylactic edema,¹⁷ hydration of protein particles in the plasma,⁹⁵ and fits produced by convulsant poisons (fits caused by nitrous oxide and curare are respiratory fits).⁹⁶ There are authors who just as definitely state that the convulsions are not caused by an excess of oxygen,^{54, 97} deep anesthesia,⁹⁷ excessive dose of atropine,⁹⁸ idiosyncrasy,⁵⁴ the use of oxygen,⁹⁹ or an excessive amount of carbon dioxide.¹⁰⁰ Rosenow and Tovell⁴¹ suggested that the condition is attributable to a neurotoxin or poison produced by streptococci in amounts insufficient to cause spasms in the absence of anesthesia, but which in the course of general anesthesia suffice to incite the muscular spasms characteristic of this condition.

It will be obvious that the confusion which exists in the literature should be only temporary. It must be possible to arrive at a decision as to the cause of this condition. In 1932, Blomfield¹⁰¹ requested "information which may lead to the explanation of their occurrence and so to their prevention." He asked that reports of convulsions during ether anesthesia be sent to him. If his suggestion had been followed, more rapid progress in the solution of this problem might have been effected. As has been said before, however, the important thing in medicine has always been to know how to treat a condition, regardless of whether its etiology is understood; in time, the former phase of the problem also will be mastered.

Since the patients have been children in at least 53 per cent of the cases in which the age was given, it would seem that this might be explained on the basis that children go into convulsions much more easily than do adults;^{6, 75} if so, the essential etiologic factor is not youth.¹⁰² I am impressed with the work of Rosenow and Tovell, and I feel that they have offered the most convincing explanation of the cause of convulsions in the cases which have been studied at the clinic. Most of the other explanations in the literature have been personal opinions. However, I wish to call this condition to the attention of those who directly or indirectly have to do with the administration of anesthetic agents, to suggest a more careful choice of preliminary medication and anesthetic agents, and to suggest the administration of a soluble barbiturate intravenously for symptomatic treatment and for the control of the convulsions so that this or additional treatment may be instituted in order to reduce the fatalities which are occurring much more commonly than has been realized.

TABLE I
CONVULSIONS ASSOCIATED WITH GENERAL ANESTHESIA

AUTHOR	CASES REPORTED	DEATHS	DIAGNOSIS OF OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR TEMP. AT	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
Ashworth	1		Acute osteomyelitis of femur*	16 M	August		Ether	Open	No impurities	Deep anes-thesia	5	Chloroform
Howman	1	1	Ruptured appendix and general peritonitis	2			Ether			A young toxic patient was deeply anesthetized		Oxygen and carbon dioxide; chloroform; oxygen
Boyle ^{1,2}	1	1	Appendicitis	9	November		Ether	Endo-tracheal		Deep anes-thesia		
Boyle ^{4,6}	1	1			February		Nitrous oxide, oxygen, and ether			Sepsis; too much ether		
Braunower	1	1					Nitrous oxide and oxygen for induction; ether for maintenance	Open				Cessation of active treatment
Brown ^{10,3}	1		Appendicitis and peritonitis	11 F	October		Atropine 1/4 gr.					

TABLE I—CONT'D

Author	Case	Patient	Anesthesia	Ether	Chloroform	(1) Carbon dioxide absorption (1) Morgan's (1) Gwathmey's	Excess of carbon dioxide	Fow	Oxygen, oxygen and carbon dioxide; morphine sulphate, 1/4 gr.
Buchanan	1	Laparotomy and repair hernia	Adult F						
Ball	1	Ducrettage	Adult F		Chloroform				
	3	General peritonitis in two cases; localized peritonitis in one case	Children			(1) Carbon dioxide absorption (1) Morgan's (1) Gwathmey's			
Clarke	5	Definite sepsis in one case	4 adults F; 1 child F		Ether administered by Morgan's method in one case; nitrous oxide and oxygen administered by Gwathmey's method in another case				
							Sex susceptibility; increased vascularity of cortex due to histamine-like effect		
Clement	1	Acute appendicitis	27 M		Nitrous oxide and ethylene and oxygen		Prolonged anoxemia	30	Digitalis; morphine sulphate, 1/4 gr.
					IL. M. C. tablet No. 1				

TABLE I—CONT'D

AUTHOR	CASES REPORTED	DEATHS	DIAGNOSIS OF OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR TEMP. AT TIME OF OPERATION	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
Clement	1		Dental extrac-tion	7			Nitrous oxide and ethylene and oxygen			Prolonged anoxemia		
	1		Dental extrac-tion	4 M								Oxygen; sodium bromide; atropine, $\frac{1}{150}$ gr.
Cook	1	1	Ruptured vena cava	29 M			Ether	Shipway's semiclosed mask		Changes in blood; deep anesthesia		Oxygen
Daly ²³	1		Gastric ulcer	20 F	July		Alcohol, chloroform, and ether; followed by ether	Ether on gauze mask; Shipway's inhaler; ether vaporized with oxygen	Acetaldehyde and peroxides	Impurities in ether; deep anesthesia		Oxygen and carbon dioxide
	1		Appendicitis		March		Ether	Open				
	1		Appendicitis with abscess		March		Ether	Open				
Daly ²³	1		Appendicitis	7 F	July	Atropine $\frac{1}{150}$ gr.	Ethyl chloride for induction; ether and oxygen for maintenance	Open		Increased cerebral vascularity		Oxygen and carbon dioxide; patient's head was raised.

TABLE I—CONT'D

Patient's name	Sex	Age	Diagnosis	Ether	Shipway's	Concentrated ether and extract of carbon dioxide	Patient's head was raised
Dawkins	1	6		Ether	Bomb		Oxygen
Dickson	1	50 M	Perforated appendix				
Evans	1	10 F	Mastoiditis with thrombosis of lateral sinus	Chloroform and ether for induction; then ether by open method	Open		
Featherstone	1	8 M	Pneumococcal peritonitis	Ether	Open	Youth, toxemia and impurities in ether	Oxygen and bromides
Haworth	1	11 M	Gangrenous appendicitis	Chloroform and ether for induction; ether and oxygen for maintenance	Shipway's	Toxemia and instability of nervous system	Chloroform and oxygen
Haworth	1	32 F	Bilateral tubo-ovarian abscess	Atropine $\frac{1}{150}$ gr., morphine sulphate $\frac{1}{16}$ gr.	Shipway's	Cerebral anemia caused by change from horizontal to Trendelenburg position	
Hewson	2			Nitrous oxide, oxygen, and ether	Endotracheal	Decomposition of ether	Carbon dioxide and oxygen

TABLE I—CONT'D

AUTHOR	CASES REPORTED	DEATHS	DIAGNOSIS OF OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR YEAR AT TIME OF OPERATION	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
Clement	1		Dental extraction	7			Nitrous oxide and ethylene and oxygen			Prolonged anoxemia		
	1		Dental extraction	4 M								Oxygen; sodium bromide; atropine, $\frac{1}{150}$ gr.
Cook	1	1	Ruptured vena cava	29 M			Ether	Shipway's semiclosed mask		Changes in blood; deep anesthesia		Oxygen
Daly ⁹²	1		Gastric ulcer	20 F	July		Alcohol, chloroform, and ether; followed by ether	Ether on gauze mask; Shipway's inhaler; ether vaporized with oxygen	Acetaldehyde and peroxides	Impurities in ether; deep anesthesia		Oxygen and carbon dioxide
	1		Appendicitis		March		Ether	Open				
Daly ⁹³	1		Appendicitis with abscess		March		Ether	Open				
	1		Appendicitis	7 F	July	Atropine $\frac{1}{150}$ gr.	Ethyl chloride for induction; ether and oxygen for maintenance	Open	No impurities	Increased cerebral vascularity		Oxygen and carbon dioxide; patient's head was raised

TABLE I—CONT'D

Case	Perforated gas- tric ulcer	Age	Sex	Date	Ether and oxy- gen	Semi-closed	Alkalosis, defi- ciency of car- bon dioxide	Rebreathing
Kemp	1	22	M	July	Ethyl chloride and ether for induction; ether for maintenance		"Acapnia the- ory," or defi- ciency of car- bon dioxide	Rebreathing
King	1	9	M	Novem- ber	Ether and oxy- gen	Semi-open	Deficiency of carbon dioxide	Chloroform and oxygen
	1	38	F		Nitrous oxide, oxygen, and ether	Closed	Idiosyncrasy	Oxygen; intra- venous admin- istration of calcium glu- conate
Kirkow	1	(Under 12)	Child- ren		Ether			
	1				Nitrous oxide, oxygen, and ether			
Laurie	1				Chloroform			
	1				Ether		Tendency to fits; lightness of anesthesia	
McDonald	1	2	F	Hot		Boyle's	Traces of peroxide	Oxygen
	1	6	F	Hot	Ethyl chloride induction; ether for maintenance		Traces of peroxide	Oxygen

SURGERY

TABLE I—CONT'D

AUTHOR	CASES REPORTED	DEATHS	DIAGNOSIS OF OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR TEMP. AT TIME OF OPERATION	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
Hosenson ¹⁰⁰	1		Ruptured ectopic gestation	31 F			Ether					Calcium chloride intravenously
	1						Ether	Semiopen		Temporary derangement of calcium metabolism		10 c.c. 10 per cent calcium gluconate intravenously
Hudson ¹¹	1		Gangrenous appendix and peritonitis	Child	Hot	Atropine	Nitrous oxide and oxygen for induction; ether for maintenance					Oxygen and carbon dioxide, calcium chloride intravenously
	1											Oxygen (discontinued ether)
Human ¹⁰⁷	1		Acute appendicitis	12 M		Atropine 1/100 gr.	Nitrous oxide, oxygen, and ethyl chloride for induction; ether for maintenance	Open				
							Ether					
Jost	6		In one case, infection of blood stream		Hot		Ether and oxygen	Intra-tracheal		Alkalosis		
Kemp ⁹	1		Perforated gastric ulcer	48 M								

TABLE I—CONT'D

AUTHOR	CASES REPORTED	DIAGNOSIS OF OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR TEMP. AT TIME OF OPERATION	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
MacKenzie ⁵⁰	10	Toxemia in all cases	Young	2 in March; 1 in October; 1 in December		Ether		Traces of impurities	Impurities in ether, degree of toxemia or septicemia		
Marriott ⁵¹	1	Acute appendicitis	20 M	6(?)	Atropine 1/400 gr.	Nitrous oxide, oxygen and ether	Carbon dioxide absorption		Oxygen, carbon dioxide; chloroform; evipal sodium 4 c.c. intravenously		
Mennell	1	Cholecystitis	Adult F			Ether and oxygen			Overetherization and overoxygenation		
	7					Ether and oxygen			Overetherization and overoxygenation	40	
Patchee	1	Amputation of fingers	39 M			Chloroform and ether	Open		Excess of carbon dioxide in system		Artificial respiration; oxygen; removal of coverings from face; chloroform
Pinsor ⁵¹	11	Acute infections in ten cases	10 young adults and child; 1 adult			Ether	Pinson's bomb in 7 cases				

TABLE I—CONT'D

Subject	1	Gangrene of skin and amputation of leg	12	November	Ether	Open	Septic element	15	Oxygen
Smith	1	Gangrenous appendix	Child		Ether		Septic element		
	1	Gangrenous appendix	Child		Ether		Septic element		
	1	Gangrenous appendix	14 M	Hot	Ether	Closed	Impurities in oxygen		Anesthetic discontinued
	1	Fecal fistula			Ether				
Sullivan	2				Ether				
	1	Menses; mis-taken diagnosis of acute appendicitis	8 M	May	Nitrous oxide and oxygen for induction; ether for maintenance	Closed		20	Oxygen, codeine, bromides
Sword	1	Lymph nodes of neck	14 F		Ether	Carbon dioxide absorption			Oxygen
Sykes	1	Pyosalpinx	28 F		Ether		Impurities in oxygen		
	1	Acute appendicitis	20 M	July	Ethyl chloride and ether	Closed	Impurities in oxygen	5-10	Oxygen and carbon dioxide; morphine; patient's head was raised
Thomas	3				Ether		Impurities in ether; over-etherization		

SURGERY

TABLE I—CONT'D

AUTHOR	CASES REPORTED	DEATHS	DIAGNOSIS OR OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR TEMP. AT TIME OF OPERATION	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
Kiddell	1		Congenital bilateral dislocation of hips	10½ F		Scopolamine 1/400 gr.; morphine sulphate 1/2 gr.	Ether Nitrous oxide and oxygen for induction; ether for maintenance	Shipway's Carbon dioxide absorption		Use of oxygen	8	Oxygen, dextrose administered intravenously
Ravenstine	1						Ether	Boyle's		Toxemia	2	Oxygen
Sapwell	1	1	Septicemia; fracture of tibia	17 F			Nitrous oxide and oxygen for induction; ether for maintenance	Closed	No impurities			Removal of cone
Sears	1	1	Gangrenous appendix	5 M			Nitrous oxide and oxygen for induction; ether for maintenance	Closed				Removal of cone; 20 c.c. of 50 per cent solution of dextrose administered intravenously
		1	Acute appendicitis with peritonitis	17 F								

TABLE I—CONT'D

Woolmer and Taylor	1	Acute mastoid- itis†	14	F 57°	Atropine 1/100 gr.		Ether	Open	3	Administration of ether dis- continued; oxygen and carbon dioxide administered
	1	Acute appendi- citis	6	F 77°	Atropine 1/100 gr.; atropine 1/150 gr.		Ethyl chloride and ether	Open	5	Administration of ether dis- continued; ox- ygen and car- bon dioxide administered
	1	Acute gangren- ous appendi- citis	39	M 84°	Atropine 1/2 gr.		Ethyl chloride and ether	Open	25	Administration of ether dis- continued; pa- tient's head was raised; oxygen and carbon dioxide and chloro- form were ad- ministered; intubation of trachea; epi- pan sodium administered intravenously
	1	Acute appendi- citis	20	F 69°	Atropine 1/100 gr.		Ether	Clover, open	10	Epinephrine, artificial res- piration; in- tubation of trachea; oxy- gen and car- bon dioxide

TABLE I—Cont'd

AUTHOR	CASES REPORTED	DEATHS	DIAGNOSIS OR OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR TEMP. AT	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
Wagner	1		Deformity of foot	14 M	July		Nitrous oxide, oxygen, and ether			Hypoglycemia		Anesthetic discontinued; oxygen and carbon dioxide administered
Walton	1		Laparotomy	8 F		Atropine $\frac{1}{100}$ gr.	Ether and chloroform	Open	Acetaldehyde and peroxide	Impurities in ether	10, 20, 20, 20 (3)	
Weber ¹¹	1		Acute appendicitis [#]	2 M			Ether				720	
Willway	1		Application of cast ^{**}	3 F		Atropine $\frac{1}{100}$ gr.	Ethyl chloride and ether	Open	No impurities	Toxemia		Oxygen and carbon dioxide
Wilson, S. R.	4	4	Acute appendicitis, in three cases; gas gangrene in one case	14, 15, 18, 21 3 M 1 F			Ether		Impurities found	Impurities in ether		
Wilson, ¹⁰ W. S.	5						Ether			Toxemia or hypoglycemia		
Wilson, ¹³ W. S.	1	1	Chronic appendicitis	5 F	March	Atropine $\frac{1}{250}$ gr.	Nitrous oxide, oxygen, and ether					Partially relieved by intravenous administration of dextrose

TABLE I—CONT'D

			11	M/October		Ethylene and oxygen					Epinephrine and caffeine, sodium benzoate
Lundy and associates	I	I									
	I	I									
	I	I	15	M	January	Morphine sulphate $\frac{1}{4}$ gr.; atropine $\frac{1}{600}$ gr.	Nitrous oxide, ethylene, oxygen, carbon dioxide, and ether	Intra-tracheal			Epinephrine, caffeine sodium benzoate; coramine, oxygen, and carbon dioxide
	I	I	8	F	April	Codeine $\frac{1}{2}$ gr.; atropine $\frac{1}{600}$ gr.	Nitrous oxide, oxygen, carbon dioxide, and ether				Sodium amylal intravenously; spinal puncture
	I	I	3	F	February	Morphine sulphate $\frac{1}{4}$ gr.; atropine $\frac{1}{600}$ gr.	Nitrous oxide, oxygen, carbon dioxide, and ether				Sodium amylal intravenously; dextrose intravenously and oxygen
	I	I	19	F	July	Morphine sulphate $\frac{1}{4}$ gr.; atropine $\frac{1}{600}$ gr.		Carbon dioxide absorption			

*Second operation, a laparotomy under ether and oxygen anesthesia, was entirely uneventful.

†Partial gastrectomy, which was performed three weeks later, produced the same phenomena.

‡Partial gastrectomy, which was performed seven weeks later under oxygen and ether anesthesia induced by the intratracheal method, produced the same phenomena.

§A second operation, which was performed six months later with the same anesthetic, did not produce any unusual symptoms. A few days after the second operation, increased traction without anesthesia produced a convulsive seizure which lasted one minute; this was followed by three seizures of shorter duration in the next few hours.

||When seen two years after the operation, the patient was an idiot of the lowest grade (not congenital) and had cerebral diplegia.

**Exploration of the os calcis, which was performed forty-eight hours later, did not produce any convulsions. This operation was performed under ether anesthesia. The ether was administered by the open method, and the preliminary medication consisted of 1/100 gr. (0.0006 gm.) of atropine sulphate.

††Tetorocle septicaemia and thrombosis of the lateral sinus developed; thirteen days after the first operation, the lateral sinus was opened under ether anesthesia, but convulsions did not occur.

‡‡A few hours after the patient left the operating room, another patient who also had acute appendicitis was operated on in the same room. Although the latter patient was anesthetized by the same anesthetic with the same machine and with the same anesthetic agents, convulsions did not occur.

TABLE I—CONT'D

AUTHOR	CASES REPORTED	DEATHS	DIAGNOSIS OR OPERATION	AGE, YEARS, AND SEX	MONTH IN WHICH OPERATION WAS DONE OR TEMP. AT TIME OF OPERATION	PRELIMINARY MEDICATION	ANESTHETIC	METHOD OF ADMINISTRATION	ANALYSIS OF ETHER	AUTHOR'S EXPLANATION OF CAUSE	DURATION OF CONVULSIONS, MINUTES	TREATMENT
Wright	1		Acute appendicitis and peritonitis	12 M	June	Atropine $\frac{1}{400}$ gr.	Ether and ethyl chloride					Patient's head was raised; lumbar puncture; oxygen and carbon dioxide; nuchal administration; intravenous
	1	1	Acute appendicitis with perforation†	4 F	July	Morphine sulphate $\frac{1}{50}$ gr.; atropine $\frac{1}{400}$ gr.	Nitrous oxide, oxygen, and ether					Dextrose and physiologic saline solution administered intravenously; epinephrine injected into heart; artificial respiration; oxygen and carbon dioxide
	1	1	Acute appendicitis	9 M	July	Morphine sulphate $\frac{1}{6}$ gr.; atropine $\frac{1}{450}$ gr.	Nitrous oxide, oxygen, and ether	Carbon dioxide absorption				Oxygen; oxygen and carbon dioxide; artificial respiration; intracardiac injection of epinephrine

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in an artery into a false sac or tissue space and thence through another abnormal opening into the venous system.

This unique circulation of the blood through the spleen suggests, as Moore⁵ points out, that the spleen is a large but modified blood vessel, subject to the same constrictions and relaxations of blood vessels elsewhere. Indeed the smooth muscle of the spleen appears to be under the same sympathetic control as the blood vessels of the splanchnic field. The spleen is markedly contracted in asphyxia, exercise, hemorrhage, and in emotional excitement, all of which are conditions associated with a constriction of the splanchnic vessels in general. Stimulation of the sympathetic nerves which run along the splenic vessels causes an immediate contraction of the musculature of the spleen, resulting in an abrupt diminution in splenic volume coincident with the sudden discharge of its corpuscle-laden blood into the circulation (Izquierdo and Cannon⁶).

Inasmuch as the blood lying within the spleen is twice as rich in erythrocytes as blood elsewhere in the body (Seheunert and Krzywanek⁷), and 50 per cent richer in hemoglobin than ordinary blood (Barcroft and Poole⁸), the discharge of this concentrated blood into the general circulation causes an increase in the number of circulating red blood cells. As the spleen can contain as much as eleven times its own weight in blood, it is evident that the circulatory blood may be greatly augmented from the spleen, by as much as 20 per cent of its normal volume.

Numerous experiments have been devised to demonstrate this phenomenon of increasing the blood volume from the splenic storehouse. Adrenalin in small amounts causes the spleen to contract and to increase the number of circulating red blood cells. After denervation of the spleen to prevent the sympathetic effect, this increase in red blood cells does not occur.

In shock produced by the crushing of thigh muscles, by crushing of the testicles, by hemorrhage, or by laparotomy, the spleen was found to be small, firm, dry, and intensely constricted, a response, no doubt, to the demand for more blood in the face of the greatly diminished circulating blood volume so characteristic in states of shock.

Viale⁹ claims that all factors which tend to raise blood pressure tend to augment or dilate the spleen, whereas all factors resulting in hypotension produce a contraction. He states that the introduction of Ringer's solution in a normal animal does not raise blood pressure, whereas in animals deprived of their spleens it does. He also states that by exteriorizing the spleen, and denervating it to abolish reflexes, the contraction of the spleen will raise the general blood pressure 15 to 20 mm. Hg.

Barcroft's and Stephens¹⁰ ingenious experiments were the first to demonstrate the remarkable reduction in the size of the spleen follow-

THE SIGNIFICANCE OF TEMPORARY ELEVATION OF BLOOD PRESSURE FOLLOWING SPLENECTOMY, WITH PARTICULAR REFERENCE TO THE RÔLE OF THE SPLEEN AS A REGULATOR OF THE CIRCULATION

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THE function of the spleen as a reservoir of blood, first suggested by Gray¹ in 1854, has only recently been thoroughly appreciated and definitely demonstrated in the interesting observations by Barcroft² and his associates. "It (the spleen) has a function entirely in conformity with its muscular structure, being in fact a reservoir of corpuscles, at once fitted by its reticulum to detain them, and by its musculature to expel them when required to do so" (Barcroft).

The anatomic structure of the spleen is peculiarly adapted to storing blood. As Robinson^{3,4} points out, the spleen is essentially a vast spongy network of pulp cells, surrounded by a capsule, and supported by a trabecular framework. These trabeculae, which contain smooth muscle and fibrous and elastic tissue, are attached to the capsule on the one hand, and to the walls of the vein on the other. Obviously, on contraction of the smooth muscle, there will be compression of the pulp tissue and distention of the veins. This fact is of particular significance when considered in connection with the absolutely unique and peculiar arrangement of the circulation of blood through this organ. According to Robinson, the terminal arterioles of each splenic lobule open out, instead of joining capillaries leading to veins, and discharge their contents directly into the spaces afforded by the spongy network of pulp cells. The venous system begins in a plexus of richly anastomosing sinuses found everywhere between the pulp cords in the peripheral portion of the lobule. The walls of the finer veins are incomplete, having slitlike stomata communicating freely with the pulp spaces. The circulation of the spleen is therefore an "open" one. The blood flows out of the circulatory bed into tissue spaces, presumably against a lesser resistance than that met by the circulating blood in the capillary bed elsewhere in the body. By contraction of the smooth muscle lying in the trabeculae, these pulp spaces are compressed, and the contained blood is forced through the fenestrated walls of the veins into the venous channels and thence into the circulation. Such an arrangement is quite comparable to a varicose aneurysm, in which blood passes from an abnormal opening

portant and the effects upon the circulation more pronounced when the spleen is twenty to forty times its normal size. Equally more important under such conditions is the close resemblance of the peculiar anatomic arrangement of the splenic circulation to that of a large varicose aneurysm. This is brought out most clearly by a study of the blood pressure following splenectomy. Theoretically, the removal of a large spleen should produce the same temporary increase in general blood pressure as does the elimination of a large arteriovenous



Fig. 2.—Demonstration of portal vessels following introduction of opaque substance in inferior mesenteric vessels of a dog. The portal vein was ligated at the hilum of the liver two months previously, one month after embedding of the spleen in the abdominal wall at S. The portal circulation reached the general circulation by a reversal of flow through the splenic vein, through the spleen and into the vessels of the abdominal wall. Note large intercostal vessels, I, and large hypogastric vessels, H, communicating with the vessels of the embedded spleen.

communication (Holman and Kolls,¹² and Holman¹³) (Fig. 1). Careful observations indicate that when splenectomy is performed as a physiologic experiment without loss of blood and without operative trauma, such a rise in blood pressure does occur. In such a physiologic experiment, the blood in the spleen itself is conserved by ligating the artery first, followed by ligation of the vein. Adhesions between

ing hemorrhage and during exercise. In cats which have a very muscular spleen, it was estimated that one-sixth of the total circulating blood volume, and one-third of the total number of red corpuscles could be expelled from the spleen. It was inferred, therefore, that "were an organism presented with an issue which made its life depend on the amount of hemoglobin it could produce, a splenectomized animal should die, when an animal possessed of a spleen should survive."

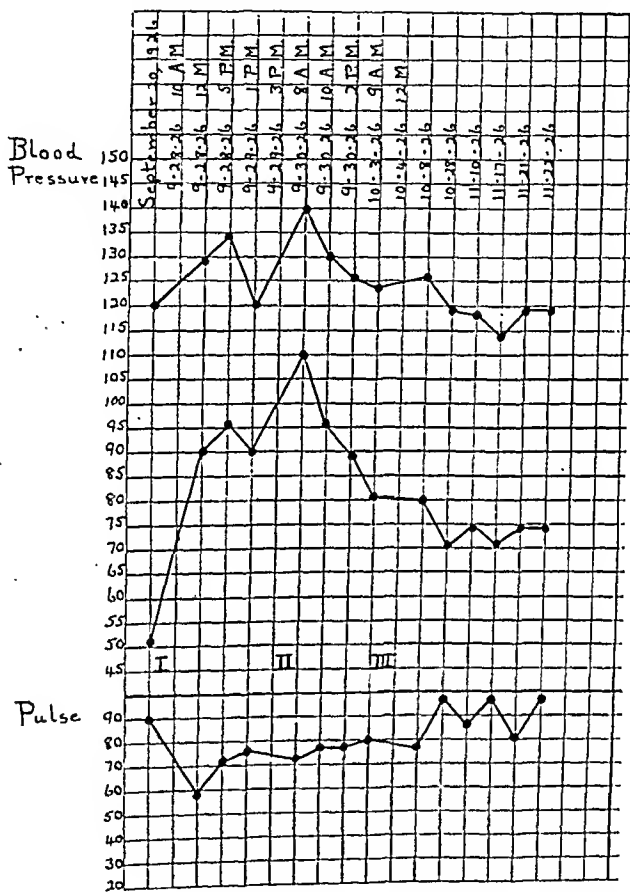


Fig. 1.—Fluctuations in blood pressure following excision of large femoral arteriovenous fistula of twenty-five years' duration. Note great increase in diastolic pressure immediately after operation and subsequent permanent elevation to a higher level. The first elevation is interpreted as being due to an increased blood volume which fills the general arterial system following the excision of the fistula, and the permanent elevation is attributed to the elimination from the circulatory system of an area of decreased peripheral resistance.

The early death of splenectomized guinea pigs placed in an atmosphere of coal gas proved the correctness of this view (Krumblhaar¹¹).

Enough has been related to indicate the remarkably intimate relationship the normal spleen bears in ordinary existence to the circulatory system. This relationship is probably correspondingly more im-

CASE HISTORIES

CASE 1.—J. B., a laborer, thirty years old, was admitted to Lakeside Hospital, Cleveland, July 25, 1925, following a fall from a third floor scaffolding to the basement below. When first seen an hour after the accident, the patient was conscious, with numerous lacerations and abrasions of the face, a fracture of the bridge of the nose, and large bruised areas of the skin over the lower left thorax and the left iliac crest. There was abdominal tenderness on the left on percussion, with spasticity, but without rigidity. Two hours later the tenderness and spasticity were greatly increased. There was a striking pallor with a pulse, however, of only

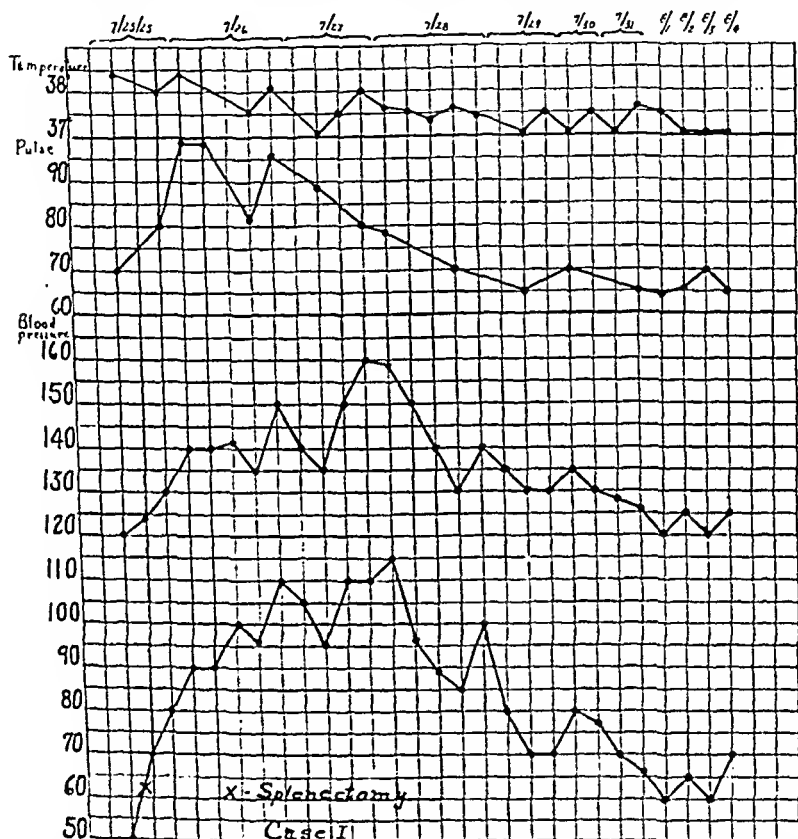


Fig. 3.—Elevation of systolic and diastolic pressures in the first five days following excision of ruptured spleen. Note resemblance to the pressure curves following excision of arteriovenous fistula (Fig. 1).

80. An exploration was immediately undertaken for a probable ruptured hollow viscus, but instead a badly lacerated bleeding spleen was found and removed, together with a large amount of free blood. During the operation the patient received about 2,500 c.c. by hypodermoclysis, but a transfusion did not seem indicated. An uneventful recovery followed. The spleen weighed 160 gm.

The striking feature of this patient was the behavior of the blood pressure following the splenectomy (Fig. 3). Since this observation, all cases requiring removal of the spleen were similarly studied.

CASE 2.—W. J., aged twenty-two years, entered Lane Hospital April 9, 1930, complaining of vomiting and passing blood, and weakness. He had been well

the spleen and surrounding structures are divided by sharp dissection. Tearing such adhesions invariably leads to rupture of the splenic capsule with massive hemorrhage from the spleen, or, more frequently, large venous sinuses leading from the splenic capsule to the posterior and lateral abdominal wall, or to the diaphragm, are torn open with terrifying bleeding. Occasionally these venous channels are extraordinarily large and numerous, suggesting that in the presence of a contracted cirrhotic liver they provide a pathway for the blood to flow from the portal system into the systemic circulation by a reversal of flow through the splenic vein, through the spleen itself, and thence into the general circulation. Experimentally such a contingency has actually been produced (Holman¹⁴) (Fig. 2).

- The rise in blood pressure during the first few days following splenectomy may be attributed to two factors: first, the elimination of an area of lessened resistance; and second, to an increase in the total volume of circulating blood which presumably has accompanied the gradually increasing bulk of spleen.

The rôle played by blood volume in the maintenance of a normal blood pressure is becoming increasingly better understood. Recent studies have shown that total blood volume is increased in hyperthyroidism,¹⁵ possibly in compensation for the peripheral dilatation with its resultant fall in diastolic pressure and concomitant increase in pulse pressure. Recent observations by Dr. Chang, of the Peiping Union Medical College, have demonstrated likewise an increase in total blood volume in several clinical cases of aortic insufficiency. Experimentally (Holman¹⁶) and clinically an increased blood volume has been noted in the presence of large fistulas between the peripheral vessels. Likewise, in the experimental animal, an increase in blood volume has followed the establishment of large interventricular septum defects (Holman and Beck¹⁷). From these observations, one is justified in concluding that any disturbance in the hydrodynamics of the circulation great enough to interfere with cardiac efficiency as shown by a lowered diastolic and systolic pressure is partly compensated for by an increase in total blood volume. Similarly, the increasing storage capacity of the enlarging spleen would affect blood pressure adversely were it not for a concomitant increase in total blood volume.

The following observations are presented to demonstrate the beneficial effect upon the general blood pressure produced by the removal of a greatly enlarged spleen. As these effects are comparable to those produced by the excision of a large peripheral fistula, corroborative evidence is provided that the spleen by virtue of the anatomy of its circulatory system may be compared to a large varicose aneurysm.

stomach were closely adherent, and were carefully dissected free. The splenic artery was isolated and divided. Immediately, the previously swollen and tense spleen became quite flaccid and shrunken in size. The adherent colon was freed and the spleen removed without the loss of any blood. The abdomen was closed in layers. The behavior of the blood pressure following the operation is recorded in Fig. 4. The white cells increased within twenty-four hours to 23,000, and on the second postoperative day signs of fluid in the lower left chest were noted. Improvement occurred, but on the fourteenth day a fever of 39° C. was noted with signs of a probable subphrenic abscess on the left. A portion of the tenth rib was resected, and the diaphragm sutured to the parietal pleura by two parallel rows of

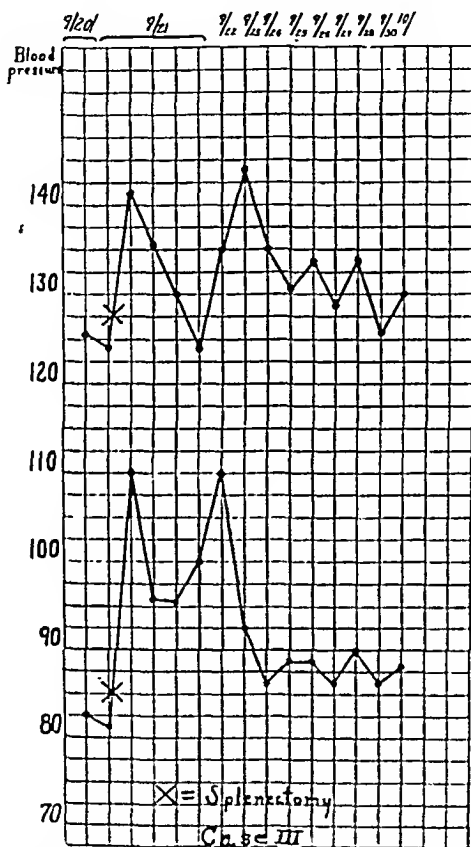


FIG. 5.—Temporary elevation of blood pressure following excision of a spleen known to be greatly enlarged for many years in a young person.

silk sutures. Three days later an incision was made parallel to and between the two rows of black sutures, and a large amount of thick creamy pus evacuated. At no time was there any infection of the abdominal wound. Cultures gave a pure growth of *Staphylococcus aureus*. The abscess cavity was treated with Dakin's solution and gradually healed. Complete recovery followed, and at the present time, this patient is in perfect health. On discharge from the hospital, the red cells numbered 4,720,000, and the hemoglobin was 87 per cent. The white cells numbered 10,100. The spleen weighed 885 gm., and showed the usual fibrosis of Banti's type.

until fifteen months previously, when he had an attack of nausea and dizziness lasting about fifteen minutes. This was promptly followed by a bowel movement containing dark red blood. Two months later he experienced another attack of nausea, followed this time by the vomiting of a quart of blood. Treatment for a probable peptic ulcer was instituted, and after two weeks in bed he again seemed quite well. Weakness, lassitude, and dyspnea then gradually developed, accompanied by a pronounced pallor. Examination revealed an enlarged palpable spleen extending four fingerbreadths below the costal margin and a marked general pallor. A hemoglobin of 20 per cent on admission increased to 38 per cent following the first transfusion, to 48 per cent following the second transfusion, and to 65 per

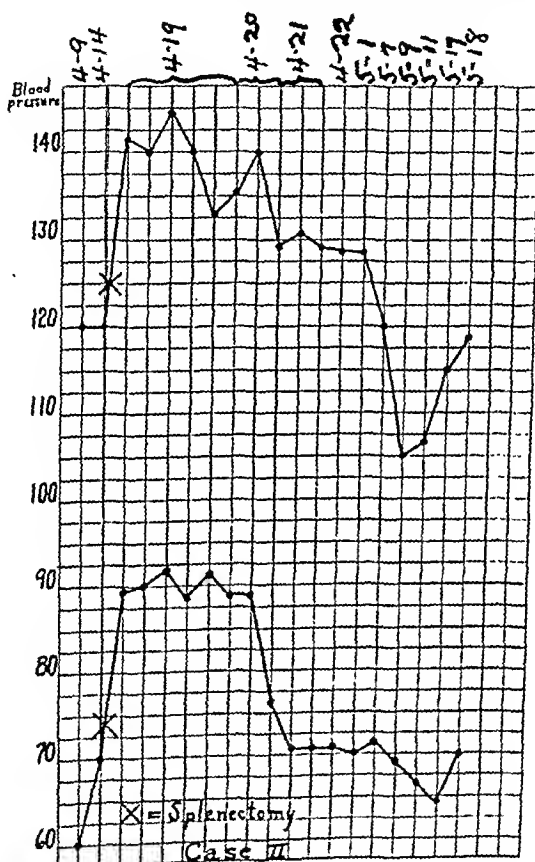


Fig. 4.—Marked temporary elevation of systolic and diastolic pressures following removal of greatly enlarged spleen of the Banti type.

cent following the third transfusion. The red cells numbered 2,140,000 on admission, increased to 2,500,000 after the first transfusion, to 3,000,000 after the second transfusion, and to 4,300,000 after the third transfusion. The white cells numbered 3,000 on admission and 4,000 after three transfusions. The fragility of the red cells was not increased; the clotting time was three minutes; and the bleeding time, seven minutes.

On April 19, 1930, a laparotomy revealed a normal sized liver with slight evidence of scarring. The gallbladder, stomach, and the viscera were normal. The spleen was greatly enlarged, appeared swollen and tense. The pancreas and

At operation, performed as a physiologic experiment, the very large spleen was removed without loss of blood. The liver was small and scarred as in cirrhosis. The operative and postoperative behavior of the blood pressure is recorded in Fig. 6. It is noteworthy that immediately after ligation of the splenic pedicle, the systolic pressure rose from 102 to 116 mm. Hg and the diastolic from 62 to 72 mm. Hg. Within a month following the operation, there occurred marked improvement in general well-being, with an increase in hemoglobin from 87 per cent to 115 per cent, in red cells from 3,900,000 to 4,800,000, in white cells from 3,000 to 7,000, and in platelets from 95,000 to 261,000. The spleen itself weighed 1,730 gm. and measured 32 by 17 by 7 cm. Microscopically it showed fibrosis with siderotic nodules. The splenic vein showed marked intimal thickening.

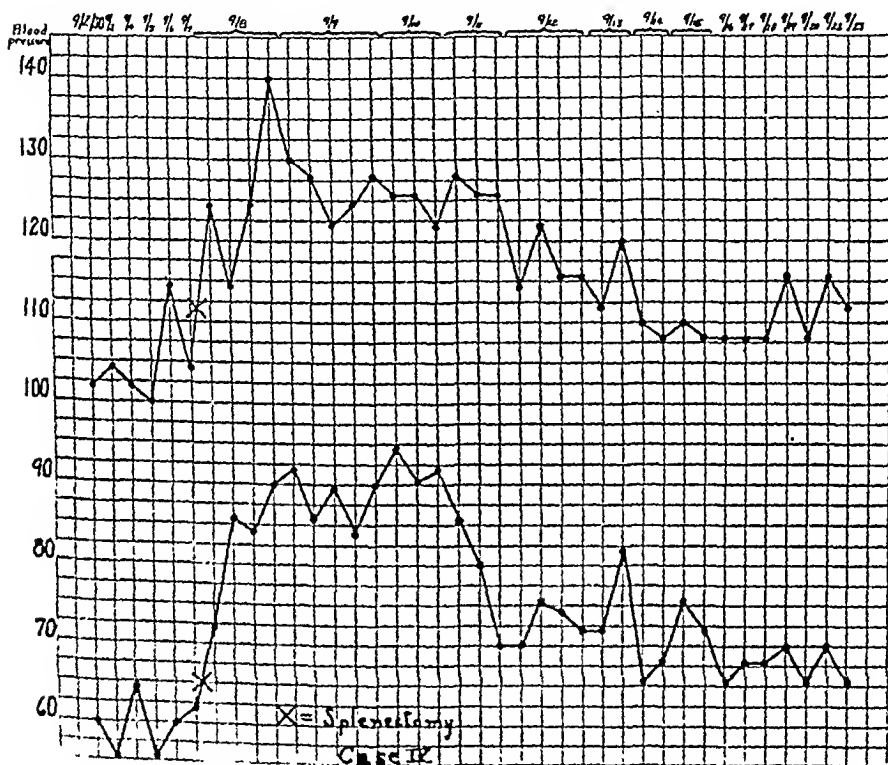


Fig. 6.—Marked elevation of systolic and diastolic pressures following removal of greatly enlarged spleen of the Banti type in an elderly Chinese.

CASE 5.—S. H., a Chinese student, nineteen years old, was admitted to Peiping Union Hospital on August 30, 1930, with the complaint of a progressively increasing abdominal mass. This mass was discovered by accident three years previously and had grown slowly in size. During this period he had had numerous attacks of fever lasting several days with morning remissions. There had been no dysentery or bloody stools. Lately there had been dyspnea, swelling of the legs at night, and marked loss of weight. Two uncles and a cousin were said to have died of the same disease.

Physical examination disclosed a pale emaciated lad with a large, hard, tense mass on the left side extending below the umbilicus. There was a moderate edema of both legs. The blood pressure was only 100/40, the pulse 100. The red cells numbered 3,800,000, the white cells, 2,500, and the hemoglobin, 20 per cent. The

CASE 3.—H. K., a married woman, aged twenty-seven years, entered Stanford Hospital September 19, 1928, with a complaint of increasing weakness, anemia, and an abdominal tumor. When seventeen years of age, in the course of a routine examination by a college doctor, she was found to have a large spleen approximately one-third its present size. At the time she was very active athletically, despite a marked pallor. She had been subject since the age of ten to attacks of "biliousness" characterized by vomiting, dizziness, headaches, and loss of appetite for several days, relieved by doses of calomel. Jaundice had been absent until last May, when she became quite yellow, and the conjunctivae wore yellow-tinged thereafter. Menstruation had been regular and not excessive. There had been no dyspnea, but she tired easily, and her knees appeared very weak. The general physical examination was normal except for a marked pallor of her skin, yellowish-tinged sclerae, and the presence of a large smooth mass in the left abdomen, emerging from below the left costal margin and extending downward to the iliac crest and medially to the umbilicus. The liver edge could just be felt.

Laboratory examinations on admission revealed a negative Wassermann reaction, a normal urine, a hemoglobin of 60 per cent, a red cell count of 2,620,000, and a white cell count of 9,150. The bleeding and coagulation time were normal, the fragility of the red cells was normal, but there was extensive anicytosis, polychromasia, and poikilocytosis.

On September 21, 1928, a laparotomy was performed through a left rectus incision. The liver was smooth, normal in size, and presented no evidence of fibrosis. The gallbladder was thickened and contained numerous small stones. The artery of the greatly enlarged spleen was exposed and ligated first, followed by ligation of the vein. During the removal of the spleen, little blood was lost, and the blood pressure became elevated instead of depressed.

The day following the operation, the patient's color was pink as contrasted with the pasty pallor previous to operation, and a certain heaviness in her limbs, which had been present for years, had disappeared. Convalescence was uneventful. The behavior of the blood pressure after operation is recorded in Fig. 5. On October 4, the red cells numbered 3,980,000, the white cells, 12,600, and hemoglobin, 72 per cent. The microscopic examination of the spleen showed a marked perivascular fibrosis of the malpighian bodies, with hematogenous pigmentation and calcification in the new hyaline fibrous tissue. The lesions in the malpighian bodies probably started as perivascular hemorrhages.

CASE 4.—S. H. C., a Chinese merchant, aged forty-five years, was admitted to Peiping Union Hospital September 2, 1930, complaining of weakness of three years' duration and a mass in the abdomen of ten years' duration. The past history was characterized by three attacks of dysentery at the age of eighteen, nineteen, and twenty years respectively, and four attacks of high fever at fifteen, eighteen, twenty-four and forty-four years of age. The slowly increasing mass in the abdomen was first noted ten years ago, and aside from the feeling of fullness had never given him any trouble. Three years ago he noted a gradually increasing weakness on walking, aggravated by a marked loss in weight during recent months.

On physical examination the patient presented a pale, wasted appearance, without jaundice. The mass in the left abdomen which extended 12 cm. below the costal margin was undoubtedly spleen. The liver was not felt. Laboratory examinations revealed a red cell count of 3,450,000; the white cells numbered 3,000, of which 65 per cent were polynuclears, 24 per cent, lymphocytes; 5 per cent, large mononuclears; and 6 per cent, eosinophiles. The bleeding time was two minutes. Two splenic punctures disclosed the absence of Leishman-Donovan bodies; the stool contained numerous ova of ascaris; and the Wassermann reaction was negative.

portal vein was postulated to explain the picture of extreme sepsis that developed, and in spite of multiple transfusions, the patient died on December 8, three months after splenectomy.

CASE 6.—W. F. S., aged thirty-six years, entered Lane Hospital March 5, 1932, because of hematemesis and tarry stools three days previously. A past history of indigestion for seven to eight years characterized by gas and pain under the sternum at first suggested the possibility of a bleeding duodenal ulcer, but a large palpable spleen, together with a leucopenia of 4,960, a red cell count of 3,420,000, and a hemoglobin of 48 per cent suggested the diagnosis of a splenic anemia. The Wassermann reaction was negative. Two preoperative blood transfusions increased the hemoglobin to 60 per cent. A roentgen ray examination of the stomach, partially distended with gas, revealed extraordinarily large veins at the cardia (Fig. 8), and an esophngoscopy disclosed large varices in the esophagus just above the diaphragm which were undoubtedly responsible for the hematemesis.



Fig. 8.—Demonstration of large esophageal varices at the cardia of the stomach which has been inflated with gas by the administration of a Selditz powder.

On March 22, a laparotomy was performed under spinal anesthesia. On opening the abdomen, large distended veins were noted in the falciform ligament, and 1 cm. to the left of the umbilicus, a rosette of large veins hung from the anterior wall covered only by peritoneum, undoubtedly the first stage in the development of a "caput medusae." A remarkable mass of dilated enlarged veins surrounded the cardia, some being $1\frac{1}{2}$ cm. in diameter. Some of these veins lay on the surface, but others dipped directly into the stomach wall, lying within and below the muscular coats. The undersurface of the diaphragm was crossed by numerous tortuous enlarged veins. The liver surface was very irregular, suggestive of considerable fibrosis. The large spleen was removed in the usual bloodless manner, the large tortuous hilar veins making the procedure somewhat difficult. The artery was ligated first, followed by ligation of the veins.

The immediate recovery was uneventful and characterized by the usual increase in blood pressure as noted in Fig. 9. On the sixth postoperative day, however, the patient complained of some epigastric distress, relieved by enemata. By the

bleeding time was six and one-half minutes, and the coagulation time twelve minutes. His platelets numbered 62,000. No Leishman-Donovan bodies were found in the spleen, but the stools contained hookworm ova.

A roentgenogram of the chest revealed evidence of tuberculosis of the lung root and adjacent parenchyma on the right side. During his stay in the hospital several attacks of epistaxis occurred, and an appreciable increase in the size of the spleen was noted.

On September 16, 1930, a splenectomy was performed. The liver was cirrhotic and small, its edge lying well above the costal margin. The spleen was large and soft. The arteries were ligated first, permitting partial emptying of the spleen before division of the vein. It was noted that the undersurface of the left diaphragm was covered with many large veins. The blood pressure showed the usual rise following division of the vessels, and at the end of the operation, it had risen from 100/40 to 120/70 (Fig. 7).

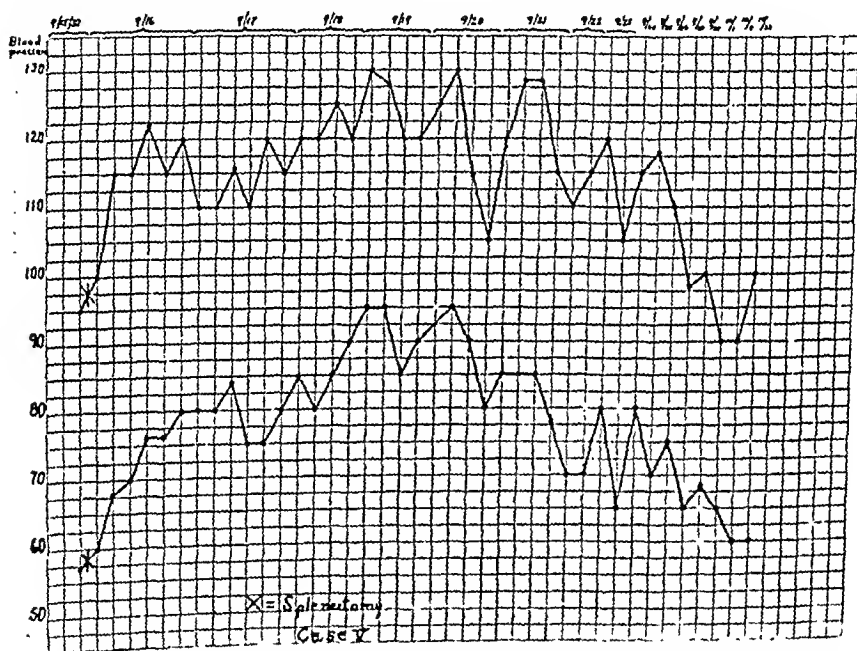


Fig. 7.—Fluctuations in blood pressure in the first ten days following removal of large spleen weighing 1,642 gm. from a young nineteen-year-old Chinese, whose liver was small and cirrhotic, and who died three months later from sepsis and marked ascites.

The spleen weighed 1,642 gm., and measured 18 by 16 by 8½ cm. Microscopical ly, it showed fibrosis and siderotic nodules, with also a marked thickening of the intima of the splenic vein.

Following operation, there developed a high fever, first ascribed to a localized abscess of the lower angle of the abdominal wound. This was drained without relief from the fever, and on October 17, a subdiaphragmatic abscess was drained by resecting a portion of the tenth rib. A pericarditis followed this procedure, and also a pleural effusion. On October 22, a blood culture yielded many colonies of *Staphylococcus aureus*. On November 4, 2,500 c.c. of straw colored fluid were removed from the abdominal cavity, which was greatly distended with fluid, as were also the tissues of the sacrum and both legs. A septic thrombophlebitis of the

ing of blood occurred seventeen times in two days. This left him weak and pale. There had never been any abnormal bleeding following wounds, and there was no history of purpura or jaundice. Encephalitis at the age of six had left him somewhat dull-witted.

Physical examination was normal, except for an obvious mental retardation and a large spleen reaching to the level of the iliac crest. Red cells numbered 2,600,000, white cells, 2,650, and the hemoglobin was 43 per cent (Sahli). The urine was normal.

On September 2, a splenectomy was performed with considerable difficulty but without loss of blood and, therefore, without shock. The transverse colon was attached to the lower border of the spleen, with huge thick-walled veins running directly from the spleen into the wall of the bowel. Similarly, very large veins lay in the gastrosplenic mesentery. Superiorly, the spleen was strongly adherent to the diaphragm, and many large vessels running from spleen to diaphragm required ligation.

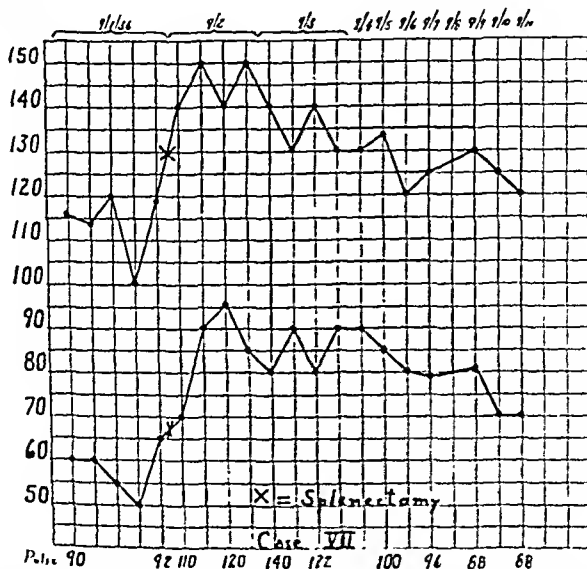


Fig. 10.—Excision of large spleen in a young eighteen-year-old male is followed by a marked temporary elevation of systolic and diastolic pressures and slight permanent increase in diastolic pressure, this being exactly comparable to the elevation of pressures following excision of a large arteriovenous fistula.

The spleen weighed two pounds, and microscopically it showed a moderate diffuse fibrous thickening of the supporting reticulum, moderately infiltrated with lymphocytes. A section of liver also showed the periportal areas infiltrated by moderate numbers of lymphocytes. Two hours after completion of the operation, the red cells numbered 4,910,000, the white cells, 15,450, and hemoglobin was 62 per cent. Four days later the red cells numbered 4,550,000, the white cells, 11,100, and hemoglobin was 73 per cent. The patient made an uneventful recovery. The blood pressure readings are recorded in Fig. 10.

SUMMARY

Recent studies attribute important functions to the spleen as a reservoir of blood and as a regulator of circulation. The "open" circulation of the spleen is unique in the body and lends itself admirably to

ninth day it was noted that the moderate distention previously relieved by enemata was no longer so controlled. Vomiting occurred for the first time, and active peristaltic waves were visible over the abdomen at regular intervals. A diagnosis of intestinal obstruction was made, which was confirmed by laparotomy under spinal anesthesia. A loop of small bowel had become firmly adherent to a mass of thrombosed veins lying in the abdominal wall just to the left of the umbilicus. At the first operation, those veins had been markedly dilated and tortuous, and were thought to be a beginning "caput medusae." A gradual occlusion of the adherent small bowel had occurred by a twisting and partial volvulus of the involved loop.

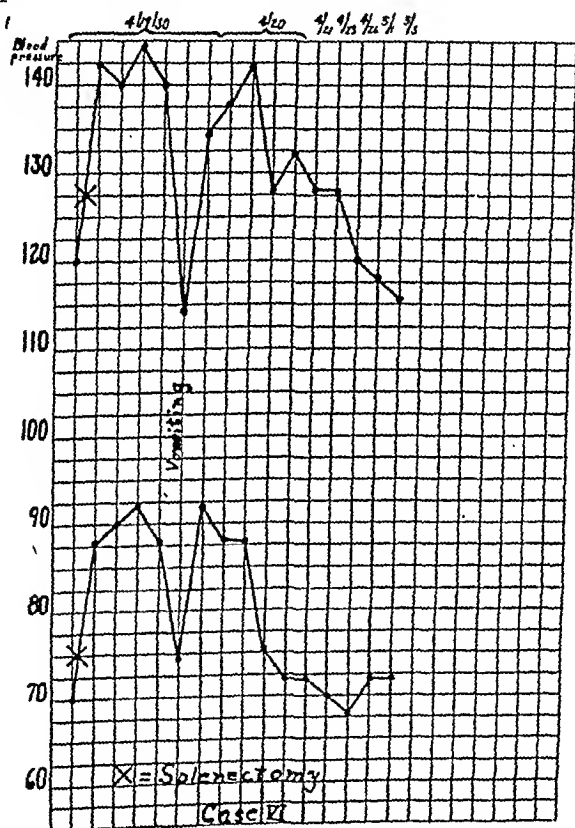


Fig. 3.—Temporary elevation of blood pressure following excision of large spleen of the Banti type. Note labile pressure during the act of vomiting.

An uneventful recovery followed with a rapid improvement in the blood picture. On May 18, 1932, slightly over a month after his discharge from the hospital, the red cells numbered 5,110,000, the white cells, 14,000, and the hemoglobin, 71 per cent; he felt very well.

CASE 7.—G. J., a young man, aged eighteen years, entered Stanford Hospital, August 29, 1936, for splenectomy. He was known to have had a large spleen for about five years. Three years ago there occurred without warning severe hematemesis on nine occasions within three days. There were no further difficulties until four months ago, when hematemesis again occurred on five occasions in twenty-four hours. Again he was symptom-free until one month ago, when vomit-

THE EFFECT OF SPLENECTOMY ON THE NUMBER OF ERYTHROCYTES AND LEUCOCYTES IN THE PERIPHERAL BLOOD OF RATS AND RABBITS UNDER ETHER AND SODIUM AMYTAL ANESTHESIA

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NARCOSIS has been shown to cause certain changes in the concentration of the cytologic constituents of the peripheral blood. Seyderhelm and Homann (1923) described a leucocytosis in rabbits which had been narcotized with ether, chloroform, morphine, and other drugs. Since that time other investigators have noted that ether narcosis produced a leucocytosis in laboratory animals other than rabbits, as well as in man. It has been suggested that this is not attributable to ether, per se, but to emotional excitement which accompanies the induction of anesthesia and forces into circulation large numbers of leucocytes which have been temporarily immobilized elsewhere in the body. Garrey and Butler found, moreover, that when animals were first narcotized with amytal and the narcosis maintained with ether, neither excitement nor leucocytosis occurred. Adrenalin causes a marked lymphocytosis and neutrophilia in the peripheral blood, which persist for varying periods of time, depending on the amount of the drug administered. This leucocytosis is thought to result from a contraction of the vessels of the entire vascular system, which effects a redistribution and a liberation of corpuscles normally sequestered in such organs as the liver, lungs, and spleen.²

Denel, Chambers, and Milhorat (1926), and Nye and Barrs (1932) noted that sodium amytal anesthesia resulted in a considerable loss of body temperature. Nye and Barrs showed that this was accompanied by a decrease in the total number of circulating leucocytes. Goldscheider and Jacob were able to demonstrate, as early as 1893, that lowering of the body temperature resulted in leucopenia. Nye and Barrs showed that the maintenance of normal body temperatures of animals anesthetized with sodium amytal failed, as a rule, to prevent the decrease in the numbers of circulating leucocytes.

Searles and Essex studied the changes in the concentration of erythrocytes in the peripheral blood of dogs which first were narcotized with ether and then with amytal. They found that when dogs were

such a function. Such an open circulation is comparable to that of a varicose aneurysm, and seven cases are presented to illustrate that the general blood pressure is elevated immediately following the removal of a large spleen in much the same way as it is following the excision of a large peripheral arteriovenous fistula. The two factors responsible for the temporary elevation of blood pressure following the excision of a varicose aneurysm or arteriovenous fistula are: (1) an increase in peripheral resistance, and (2) distention of the circulatory bed by the volume of blood which has increased in the presence of the fistula. It is suggested that the same factors are probably responsible for the elevation of blood pressure following splenectomy, and that proceeding *pari passu* with the gradually increasing storage capacity of an enlarging spleen, there occurs a gradually increasing total blood volume.

The remarkable concentration of blood following splenectomy, as exemplified in Case 7, suggests that this increase in blood volume is largely one of dilution, and that the low red cell count and anemia accompanying splenomegaly may be due in part to a storage of red cells in the greatly enlarged spleen.

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RESULTS

The data assembled from our counts of the numbers of erythrocytes and leucocytes in the peripheral blood of rats subjected to ether and sodium amytal anesthesia before and after the removal of their spleens have been condensed into Table I. The comparable data assembled from our study of the blood of the rabbits likewise have been tabulated in Table II. The figures recorded represent the means of all counts made, together with their probable errors. When the differences between the mean blood counts of normal animals under ether and under amytal anesthesia were computed, it was clear (with the exception of the erythrocyte counts of rabbits) that the blood counts of amytalized animals were significantly lower than were those of the same animals when etherized (Tables I and II). This is in accord with established findings.

TABLE I
STUDY OF THE PERIPHERAL BLOOD OF THIRTY-FIVE RATS

THIRTY-FIVE RATS WHOSE SPLEENS WERE INTACT			TWENTY-THREE RATS WHOSE SPLEENS HAD BEEN REMOVED*		
MEAN VALUE AND PROBABLE ERROR		DIFFERENCE	MEAN VALUE AND PROBABLE ERROR		DIFFERENCE
AFTER INDUCTION OF ETHER ANESTHESIA	AFTER INDUCTION OF AMYTAL ANESTHESIA		AFTER INDUCTION OF ETHER ANESTHESIA	AFTER INDUCTION OF AMYTAL ANESTHESIA	
Erythrocytes per c. mm. of blood					
9,382,850 ±73,160	8,792,770 ±34,540	590,000 ±80,900	9,334,340 ±139,325	8,887,390 ±159,908	446,957 ±212,000
Leucocytes per c. mm. of blood					
38,902 ±987	25,864 ±747	13,038 ±1,238	33,026 ±947	28,826 ±953	4,200 ±1,343

*Only twenty-three of the thirty-five rats were subjected to splenectomy.

TABLE II
STUDY OF THE PERIPHERAL BLOOD OF TWELVE RABBITS

TWELVE RABBITS WHOSE SPLEENS WERE INTACT			NINE RABBITS WHOSE SPLEENS HAD BEEN REMOVED*		
MEAN VALUE AND PROBABLE ERROR		DIFFERENCE	MEAN VALUE AND PROBABLE ERROR		DIFFERENCE
AFTER INDUCTION OF ETHER ANESTHESIA	AFTER INDUCTION OF AMYTAL ANESTHESIA		AFTER INDUCTION OF ETHER ANESTHESIA	AFTER INDUCTION OF AMYTAL ANESTHESIA	
Erythrocytes per c. mm. of blood					
5,582,500 ±74,090	5,319,166 ±84,740	263,334 ±112,950	5,557,600 ±101,929	5,737,777 ±55,652	119,889 ±116,150
Leucocytes per c. mm. of blood					
15,925 ±1,070	10,342 ±617	4,683 ±1,235	18,522 ±1,670	11,822 ±715	7,700 ±1,816

*Only nine of the twelve rabbits were subjected to splenectomy.

etherized there was an increase of 18 per cent in the volume of the erythrocytes, an increase of 19 per cent in concentration of hemoglobin, and an increase of 15.5 per cent in the total number of erythrocytes per cubic millimeter of blood. When the same animals were anesthetized with sodium amytal, the volume of the erythrocytes was found to be reduced on the average by 21 per cent; the concentration of hemoglobin was decreased 21 per cent; and the erythrocyte count was decreased 19.7 per cent. They further showed that the removal of the spleen from these dogs abolished these changes.

Essex, Seeley, Higgins, and Mann then studied the effect of anesthesia on the peripheral blood in a series of dogs, part of which had been splenectomized some time previously. Their results were in accord with those of Searles and Essex, and they concluded that ether induced a profound constriction of the spleen which forced sequestered corpuscles into the circulation, while sodium amytal induced a dilatation of the spleen. Hausner and Essex have shown by roentgenograms that marked changes in the size of the spleen do occur in dogs which have been anesthetized with ether or sodium amytal.

In order to test further the rôle of the spleen in controlling the concentration of the cytologic constituents of the blood, we have counted the total numbers of erythrocytes and leucocytes in the peripheral blood of rats and rabbits under ether and sodium amytal anesthesia, before and after the removal of the spleen.

METHOD

Thirty-five healthy male rats and twelve normal rabbits were used in this study. All of the rats were etherized in a glass container, and after complete anesthesia had been induced, the right leg was shaved and a sample of blood for the total erythrocyte and leucocyte counts was withdrawn from the femoral vein. At the same time on the following day, the same animals were given subcutaneously a solution of sodium amytal in amounts equal to 75 mg. per kilogram of body weight. The drug was readily absorbed, and as soon as complete anesthesia was induced, samples of blood were again taken, this time from the left femoral vein, and the erythrocyte and leucocyte counts were made.

The spleens were then removed from twenty-three of these rats. On the first day after splenectomy, and before any evidence of Bartonella anemia was apparent, the animals were anesthetized with ether, and twenty-four hours later they were anesthetized with sodium amytal. The blood counts were again determined in the same way as they were before splenectomy.

The procedure on the rabbits was exactly the same as that on the rats, except that blood was taken from the vein of the ear, and the amytal was given intravenously in doses of 50 mg. per kilogram of body weight. Only nine of the rabbits were splenectomized.

a significant effect. The mean percentage increase of the number of leucocytes in the blood of etherized normal rats over that recorded when the same animals were given amytal was 47.90 ± 5.04 per cent. After the spleens had been removed, this increase dropped to 28.42 ± 3.57 per cent. Between these percentages there is a difference of 19.48 ± 6.25 , and since the difference is more than triple its error, the conclusion is indicated that splenectomy induced an effect on the concentration of the leucocytes in the peripheral blood of rats which were subjected to the two anesthetics.

Analyzing the data on the blood of rabbits from the standpoint of percentage increase in the blood counts of animals under ether over the figures obtained when the rabbits were given amytal showed that there was no significant difference after the spleen had been removed. In other words, removal of the spleens of rabbits failed to alter significantly the differences which occurred between the total number of erythrocytes per cubic millimeter or the total number of leucocytes per cubic millimeter when the rabbits were under ether anesthesia and under sodium amytal anesthesia.

Thus, when we contrast the blood count of rats which were under the influence of these two anesthetics, before and after splenectomy, it seems apparent that splenectomy had little effect on the concentration of the erythrocytes, but that it had a marked effect on the concentration of the leucocytes in the peripheral blood. Differences in the leucocyte count under the two anesthetics, which were so apparent when normal rats were studied, were not so marked after the spleens had been removed.

Splenectomy, however, appeared to be without effect on the concentration of corpuscles in the peripheral blood of rabbits. No significant difference was observed between the total erythrocyte counts of either normal or splenectomized rabbits which were under the influence of the two anesthetics. With regard to the total number of leucocytes, we found an even greater difference between the number of leucocytes in blood of splenectomized rabbits under the two anesthetics than we did before we removed the spleens.

COMMENT

Our data show that when rats were anesthetized with sodium amytal, their blood counts were always significantly lower than they were when the rats were anesthetized with ether. Coincident with this observation is the fact that the spleen is invariably enlarged in rats which are given sodium amytal and considerably smaller in these same animals when they are under the influence of ether. Hansner and Essex have shown, by means of roentgenograms, that the spleen of the dog dilates when the animal is given sodium amytal, and that it contracts when the dog is under the influence of ether.

When the spleen was removed and the blood examined shortly after splenectomy, we learned that the difference between the average erythrocyte count of etherized and amyralized rats was nearly as great as it had been before splenectomy (Table I). The removal of the spleen, however, had a more marked effect on the concentration of the leucocytes in the peripheral blood. Before splenectomy, the mean leucocyte count under amyral anesthesia was 13,038 per cubic millimeter less than it was when the same rats were etherized. After splenectomy, this figure dropped to 4,200 (Table I). Thus it follows from a statistical analysis of the data that such significant differences as appeared in normal rats under the two anesthetics were not quite so obvious after the spleen had been removed as they were before. Differences, however, still maintained.

We encountered no significant difference in the number of erythrocytes in the peripheral blood of normal rabbits when observed under ether anesthesia and under sodium amyral anesthesia (Table II). After the spleen had been removed, these counts remained statistically alike when the blood was studied while animals were under each of the two anesthetics. To be sure, the total number of erythrocytes was found to be less when the rabbits were amyralized than it was when they were etherized, but the difference was slight, and its probable error was great. The number of leucocytes in the blood of normal rabbits was significantly less when they were amyralized than it was when they were etherized, but after removal of their spleens, a significant difference still persisted. In fact, after splenectomy we secured an even greater discrepancy between the leucocyte count under ether and that under amyral.

We then computed for each animal the percentage of increase in the blood counts induced by ether over those induced by sodium amyral. When the mean of these percentages was determined, we found that the erythrocyte count of normal rats which were anesthetized with ether was 6.19 ± 0.80 per cent higher than it was when the same animals were anesthetized with sodium amyral. After the spleens had been removed, the erythrocyte count under ether was still 3.64 ± 0.94 per cent higher than it was under sodium amyral. Thus, the percentage increase in the total erythrocyte count of animals under ether over the total erythrocyte count found when they were under amyral was less after the spleens had been removed than it had been before. The difference between these percentage increases, however, computed statistically, was not significant; therefore, we may conclude that the removal of the spleens was without significant effect on the distribution of the erythrocytes.

When we contrasted the percentage increases in the total number of leucocytes found in the blood of etherized rats over that found in the blood of amyralized rats, the removal of the spleen appeared to have

Recently, Svirbely and Bollman have shown that there are significant differences in the plasma volume and the hematocrit determinations for dogs, first studied under ether and then under sodium amytal anesthesia. When dogs were etherized, these writers found an increase in the hematocrit value and a decrease in the volume of the circulating plasma. Conversely, when the dogs were subjected to sodium amytal narcosis the hematocrit value, or volume of erythrocytes, decreased considerably, and the plasma volume increased markedly. These observations have a significant bearing on our study. With an increase in plasma volume, a dilution in the circulating elements will occur, and thus a decrease in total cellular constituents will occur. The increase in plasma may likewise well account for the distended spleen seen in amytalized animals. When Svirbely and Bollman removed the spleens from these same dogs and again determined their hematocrit value and plasma volume under the two anesthetics, they found changes which were similar to, but less marked than, those which occurred in normal animals. Our observations on the rat are in accord with these conclusions on the dog and indicate that the spleen plays a part in regulating the control of the concentration of some of the cytologic constituents of the peripheral blood.

SUMMARY AND CONCLUSIONS

The total numbers of erythrocytes and leucocytes per cubic millimeter of blood have been determined for white rats and for rabbits subjected to ether and sodium amytal anesthesia, before and after removal of their spleens.

With the exception of the number of erythrocytes in rabbits, we have found the blood counts in intact animals significantly lower when they were under amytal than when they were under ether anesthesia.

By the removal of the spleen we have tested the rôle played by this organ in the sequestration of both the erythrocytes and the leucocytes from the blood stream of these animals when they were subjected to ether and sodium amytal anesthesia.

The following conclusions seem indicated:

1. The removal of the spleens from white rats caused but little decrease in the difference between the erythrocyte counts noted when normal animals were subjected to these two anesthetics. The removal of the spleens from rabbits was without effect on the differences which occurred in our tabulation of erythrocytes in normal animals under the two anesthetics. The spleen is not an important site for the sequestration of the erythrocytes from the peripheral circulation of rats and rabbits under sodium amytal anesthesia.

2. The removal of the spleens from white rats induced a significant reduction in the difference in the number of leucocytes normally encountered in the peripheral blood of animals under ether and sodium

It is a reasonable assumption, therefore, that blood corpuscles may be sequestered in the dilated sinuses of the spleen when the animal is anesthetized with amytal. This reduces the number of corpuscles per cubic millimeter in the peripheral blood. Conversely, the contraction of the spleen, when the animal is given ether, may force from this organ those corpuscles temporarily isolated and thus elevate the blood count in the peripheral blood. Thus, the removal of the spleen from the circulation would give some measure of its rôle in controlling the concentration of corpuscles in the peripheral blood when the animal is under these two anesthetics.

When the spleen was removed from rats the difference between the erythrocyte counts under the two anesthetics was only slightly less than it was in intact animals before operation. When the data were contrasted from the standpoint of percentage increase in the erythrocyte count when the rats were under ether, over and above the erythrocyte count when the rats were under sodium amytal, we found that whereas the increase was less after the spleen was removed, the difference when computed statistically was not significant.

In the rat, therefore, we concluded that splenectomy was without significant effect on the concentration of the erythrocytes in the peripheral blood when the animal was under these two anesthetics.

With respect to the numbers of leucocytes, the data show that removal of the spleen did have a marked effect on their concentration. A difference of 13,038 leucocytes per cubic millimeter of blood was recorded for normal rats which were under the two anesthetics, and after the spleen was removed this difference dropped to 4,200 leucocytes per cubic millimeter of blood. When the percentages of increase in the total number of leucocytes were computed, we found that the figures were significantly less in animals from which the spleens had been removed.

Our data for the concentration of the corpuscles in the peripheral blood of rabbits indicate that in this animal the spleen is not a factor in the sequestration of corpuscles during sodium amytal anesthesia. With regard to the erythrocytes, there were no significant differences between the total counts for animals under the influence of the two anesthetics, either before or after the removal of the spleens. With regard to the leucocytes, however, we found a considerable difference between the counts before the animals were operated on, but an even greater difference after the spleens had been removed. Accordingly, splenectomy was without effect, so that we must look elsewhere than the spleen for factors which regulate the concentration of leucocytes in the peripheral blood of the rabbit. The spleen of the rabbit is, of course, very much smaller in respect to body size than is the spleen of the rat, and it may be that because of its size, it plays no significant part in modifying the concentration of leucocytes in the peripheral blood.

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The total numbers of erythrocytes and leucocytes per cubic millimeter of blood have been determined for white rats and for rabbits subjected to ether and sodium amytal anesthesia, before and after removal of their spleens.

With the exception of the number of erythrocytes in rabbits, we have found the blood counts in intact animals significantly lower when they were under amytal than when they were under ether anesthesia.

By the removal of the spleen we have tested the rôle played by this organ in the sequestration of both the erythrocytes and the leucocytes from the blood stream of these animals when they were subjected to ether and sodium amytal anesthesia.

The following conclusions seem indicated:

1. The removal of the spleens from white rats caused but little decrease in the difference between the erythrocyte counts noted when normal animals were subjected to these two anesthetics. The removal of the spleens from rabbits was without effect on the differences which occurred in our tabulation of erythrocytes in normal animals under the two anesthetics. The spleen is not an important site for the sequestration of the erythrocytes from the peripheral circulation of rats and rabbits under sodium amytal anesthesia.

2. The removal of the spleens from white rats induced a significant reduction in the difference in the number of leucocytes normally encountered in the peripheral blood of animals under ether and sodium

amytal anesthesia. The removal of the spleens from rabbits did not reduce the difference in the total leucocyte counts under similar conditions. Thus when sodium amytal is employed, the spleen plays an important rôle in the sequestration of leucocytes in rats but not in rabbits.

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BENIGN TUMORS OF THE STOMACH*

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BENIGN tumors of the stomach have been classified by Carli³ in terms of their origin: (1) those originating from epithelium include papilloma and adenoma; (2) those originating from connective tissue and vascular structures include lipoma, fibroma, myxoma, and angioma; (3) while those arising from neuromuscular structures are the myomas and neuromas. Tumors of the latter group, or those arising from muscular structure in the gastric wall, occur with the greatest frequency and comprise approximately 60 per cent of all benign tumors of the stomach. Those of epithelial origin comprise approximately 30 per cent of all benign gastric tumors. In 1925, Eliason and Wright⁶ collected from the literature and analyzed 560 various benign tumors of the stomach in which this relative frequency was borne out. Judd and Hoerner⁸ recently reported 50 cases of benign tumor of the stomach exclusive of polyposis, cysts, and hypertrophy of the pyloric muscle encountered at operation, in which the various tumors of muscular origin comprised 72 per cent of the series.

The incidence of benign tumors of the stomach depends largely upon whether it is determined from surgical pathologic material or from findings at necropsy. From a surgical viewpoint, the benign tumors comprise from approximately 0.5 per cent to 5 per cent of all gastric neoplasms, either as the major surgical lesion or as one encountered in the stomach incident to a surgical procedure for major pathology elsewhere in the abdomen. Balfour and Henderson,¹ in 1927, reported a total of 58 cases of benign tumor of the stomach. These included 26 surgical cases previously reported by Ensternan and Senty,⁷ which the latter authors stated represented 1.3 per cent of approximately 2,146 gastric neoplasms surgically explored. During the period of time in which these instances of gastric neoplasms were accumulated, however, a slightly larger number of cases of malignant neoplasms were not operated upon because of inoperability in the majority, making an actual incidence of approximately 0.6 per cent of all gastric neoplasms. Also in Eiselsberg's² Clinic there were only five benign tumors among 1,125 gastric neoplasms, an incidence of 0.44 per cent. On the other hand, Lockwood¹¹ has stated that in a period of seven years, 12 benign gastric tumors were examined in the laboratory of the Harper Hospital, Detroit, during which time 266 cases of malignant

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gastric tumors were admitted to the hospital, an incidence of benign tumors among gastric neoplasms of 4.3 per cent. Moura, De Brito, and Lopes²¹ have reported 3 benign tumors of the stomach which represent 4.1 per cent of a series of 73 gastric neoplasms on the service of Professor Brandao-Filho. The majority of the large number of benign tumors of the stomach recorded in the literature have been found at autopsy and include those which were primarily responsible for death as well as those which during life were entirely symptomless and were found more or less incidentally at necropsy. What the true incidence of benign tumors of the stomach actually may be is unknown. The studies and observations of Rieniets²³ reveal a startlingly high incidence when intensive search for them at necropsy is instituted. Leiomyomas were found in 16 per cent of the stomachs in each of two series of 100 consecutive autopsies. Rigler and Erickson,²⁴ after investigating the records of 6,742 autopsies over a period of four years in the Department of Pathology of the University of Minnesota, found that there were 187 gastric neoplasms of which 138 were malignant tumors and 47 were benign, an incidence of benign tumors of 26 per cent of all gastric neoplasms. It is quite apparent that benign tumors of the stomach are not uncommon, but those which give rise to clinical manifestations of sufficient magnitude to lead to clinical or surgical recognition occur with relative infrequency.

CLINICAL MANIFESTATIONS

As the large number of instances found at autopsy and incident to other abdominal surgical procedures would indicate, most benign tumors of the stomach are symptomless. When symptoms do occur, they not infrequently are entirely bizarre, or present ulcer manifestations, or clinical evidence of bleeding either as one or more massive hemorrhages, or occasional tarry stools and anemia; or intermittent pyloric obstruction occurs as a result of the location or size of the tumor. Cornil,⁴ Bernabei,² Meyer and Singer,¹⁶ and Matas¹³ are among those who have directed attention to the manner in which a pedunculated tumor near the pylorus may serve as a ball valve or pass through the pylorus and produce intermittent gastric ileus.

Bleeding has been a prominent symptom and one which has led to clinical recognition and operation in many cases. The bleeding in some instances has been due to erosion of mucous membrane overlying the tumor and has been of such a nature as to produce an anemia which has not infrequently exhibited a blood picture closely simulating that of pernicious anemia. In others, massive hemorrhages have occurred. Miodowski,¹⁷ Niemeyer,²² Kemke,⁹ Morgan,²⁰ and Melnick,¹⁴ and others have cited instances in which fatal hemorrhage has occurred from a benign tumor of the stomach.

Often when symptoms simulating those of peptic ulcer occur, a peptic ulcer is actually present. Lockwood,¹¹ Meyer and Rosi,¹⁵ Balfour,¹ Lorenz,¹² and others have presented such observations. Judd and Hoerner⁸ stated that gastric or duodenal ulcer was associated in 46 per cent of their cases of benign tumor of the stomach. In eight cases, the gastric ulcer was situated directly over the neoplasm. In six of these, Rieniets²³ stated that the ulcer extended through the mucosa, muscularis mucosa, submucosa, the capsule of the tumor, and into the tumor tissue. One of these cases Judd and Hoerner⁸ presented in detail as an illustration of gastric ulcer penetrating a leiomyoma. While duodenal or gastric ulcer is at times associated with a benign tumor of the stomach, and while erosion of mucous membrane overlying the tumor with ulcer formation has been noted in a number of cases, deep penetration of the tumor by a gastric ulcer has been observed so infrequently as to warrant recording a case of gastric ulcer deeply penetrating a large leiomyoma of the stomach and from which several massive hemorrhages had occurred.

CASE REPORT

CASE 1.—The patient, Mr. C. H. S., fifty-six years of age, was examined on April 13, 1936, and stated that he had been entirely well until about three years previously, when he developed a digestive disturbance which was quite characteristic of peptic ulcer and for the relief of which on his own accord he resorted to the use of alkalis. He likewise experienced ease by the taking of food. Several weeks after the onset of the epigastric distress, a rather massive hemorrhage occurred, as was manifested by tarry stools, weakness, and anemia. The patient's physician advised roentgenologic study of the gastrointestinal tract, which the patient failed to have done. A clinical diagnosis of a peptic ulcer was made, and a medical regimen was instituted with complete relief of all symptoms until six months later when hemorrhage recurred and was manifested by tarry stools. Bleeding had occurred in variable amounts at intervals of several months, and except for the occasional hemorrhages, few if any symptoms had been manifested. The patient seldom had nausea or vomiting and never had vomited blood. Upon examination the patient was found to be well nourished, weighed 163 pounds, and was moderately anemic. The systolic blood pressure was 164, and the diastolic pressure 82. General physical examination was essentially negative. No epigastric mass was palpable, nor was tenderness demonstrable.

The patient was admitted to St. Vincent's Hospital for further study. Urinalysis showed specific gravity 1.006, acid reaction, no albumin, sugar, acetone, or microscopic elements. The concentration of the hemoglobin was 45 per cent, the erythrocytes numbered 3,340,000 in each cubic millimeter of blood, and the leucocytes numbered 5,750. The differential count was as follows: neutrophils, 63 per cent; lymphocytes, 30 per cent; eosinophils, 4 per cent; and basophils, 1 per cent. The bleeding time was one minute, and the coagulation time was three and one-half minutes. Roentgenologic examination of the stomach by K. S. Davis showed a niche on the greater curvature of the stomach 2.5 cm. above the pylorus (Fig. 1). There was no six-hour gastric retention. The roentgen diagnosis was gastric ulcer; malignant 50 per cent.

At operation, April 16, 1936, there was a tumor approximately 9 by 4 by 4 cm. in diameter situated near the pylorus and involving the greater curvature and the

anterior wall of the stomach. The tumor appeared to be entirely intramural and exhibited no gross evidence of a malignant lesion. Exploratory gastrotomy revealed a large gastric ulcer deeply penetrating the tumor. A partial gastrectomy was performed and resection of the pyloric fourth of the stomach facilitated wide excision

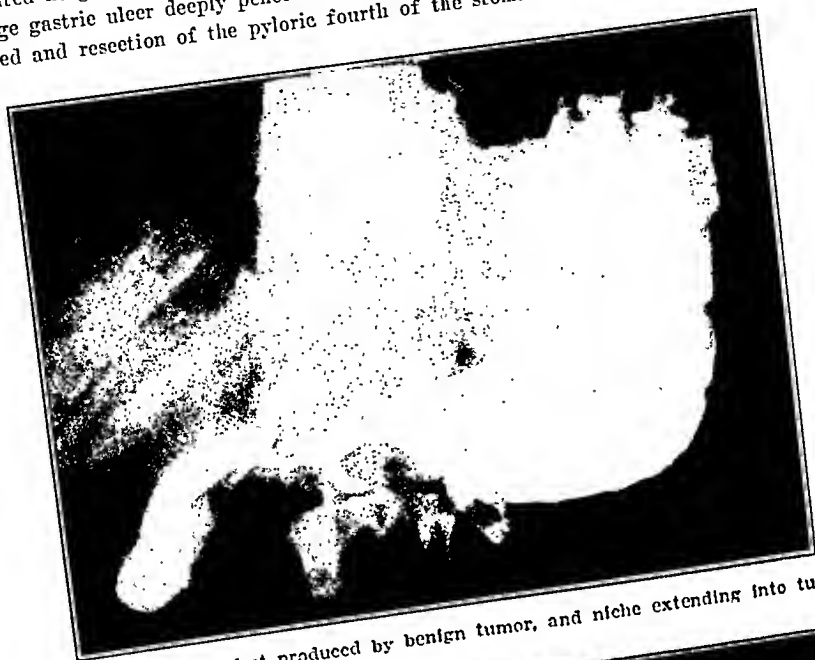


Fig. 1.—Filling defect produced by benign tumor, and niche extending into tumor.

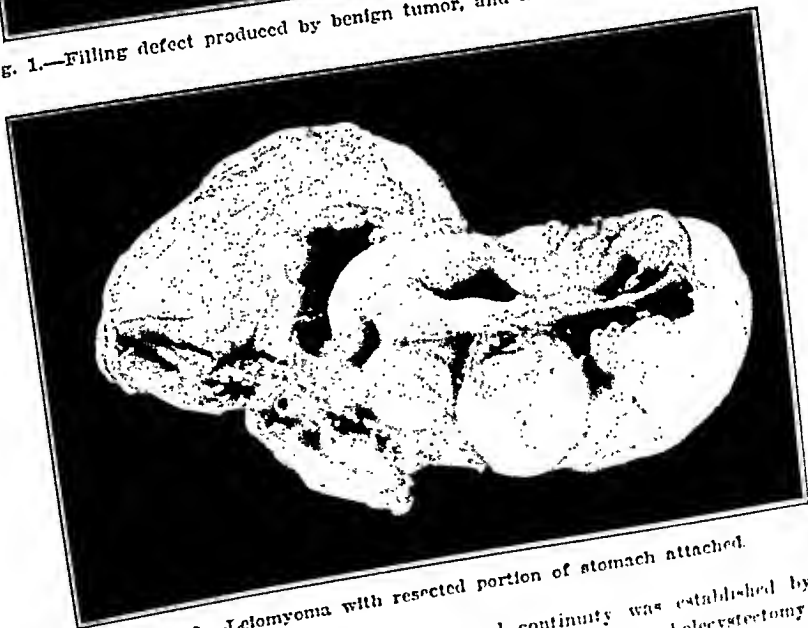


Fig. 2.—Leiomyoma with resected portion of stomach attached.

of the tumor. Restoration of gastroduodenal continuity was established by the Billroth No. I method. Gallstones were associated, and a cholecystectomy was performed simultaneously with the gastric resection. The convalescence was complicated by a bronchopneumonia. The patient, however, was dismissed from the

hospital in excellent condition on May 18, 1936, the thirty-second postoperative day. Six months following the operation the patient was seen again and was in splendid health.

The pathology of the tumor of the stomach was described by Dr. John W. Budd as follows: Gross description: The tumor measured 6.5 by 4 by 3 cm. in diameter (Fig. 2). Its surface was coarsely lobulated and was covered by a thin transparent capsule over about three-fourths of the periphery. The tumor was firm but elastic in consistency, pinkish-white in color, and cut sections exposed an opaque homogeneous surface striated by bands of fibers running in many directions. There was no degeneration or hemorrhage. The concave surface of the tumor was covered by a thin layer of gastric mucosa which was densely adherent to the tumor. In about the



Fig. 3.—Low power of gastric ulcer extending into the leiomyoma.

midpart of the mucosa, there was a linear depression 3 cm. in length and 4.5 mm. in width which at each extremity hollowed out to form a concavity 1 by 0.4 cm. in diameter. These concavities were well within the substance of the tumor. In one instance, the mucosa was apparently intact, but greatly thinned out, while in the other it seemed to be defective and ulcerated (Fig. 3).

Microscopic description: The tumor tissue was composed of bundles of mature smooth muscle cells which were supported by moderately dense fibrous stroma (Fig. 4). At the periphery, there was a thin envelope of dense fibrous connective tissue which separated the tumor from the surrounding tissues. Sections taken through the ulcer showed a membrane of fibrinous exudate and polymorphonuclear leucocytes covering the epithelial defect. The base of the ulcer was formed by tumor tissue

which showed moderate fibrosis and nodules of round cell infiltration. At the margins, there was an intact but atrophic layer of gastric mucosa and submucosa, the latter rather densely scarred.

Diagnosis: Leiomyoma of the stomach, apparently arising from the muscle wall, and peptic ulcer of the gastric mucosa with extension into the substance of the leiomyoma.

DIAGNOSIS

There are no clinical characteristics of benign tumor of the stomach. Usually a tumor is not palpable, and in the absence of a palpable mass,

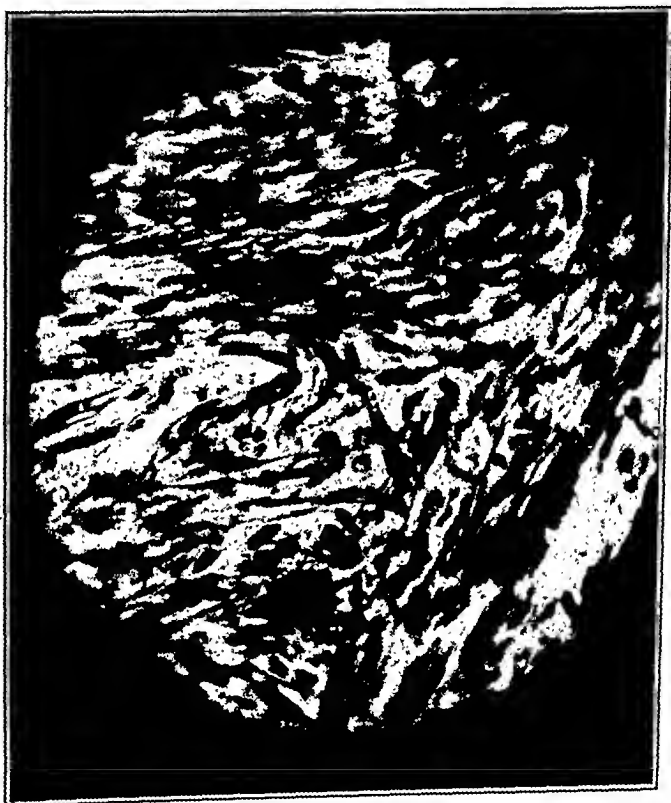


Fig. 4.—High power of the leiomyoma showing the muscle cells in longitudinal section

the clinical manifestations when present often suggest gastroduodenal disease either through ulcer features, anemia, gastrointestinal bleeding, or disturbance of gastric motility. Fortunately the roentgenologic aspects of benign tumors of the stomach have become sufficiently established to facilitate the diagnosis in many instances. Moore,¹⁸ Rigler and Erickson,²¹ Kirklin and Weber,¹⁹ and others have contributed valuably to the roentgen diagnosis of benign tumors. The roentgenologic criteria of benign tumor of the stomach are of particular interest to the roentgenologist, but the surgeon's temerity may be somewhat enhanced in favor of surgical exploration if he is familiar

with some of the roentgenologic criteria which differentiate benign from malignant tumors of the stomach. Moore¹⁹ has stated that conspicuous among the signs of benign tumor are: (1) the filling defect is generally central rather than marginal, and although it may be near the curvature, it is smoothly and sharply contoured and is commonly rounded or oval; (2) the outline of the gastric shadow is usually preserved, although it may be faint; exceptions are mural or broadly sessile tumors which through exclusion of barium from their base produce a marginal defect; (3) absence of spasm common to ulcer and carcinoma; and (4) uninterrupted peristalsis.



Fig. 5.—Multiple polypoid tumors of the stomach (Case 2).

The importance of the early diagnosis of benign tumors of the stomach is twofold. Those tumors giving rise to symptoms are so situated in most instances that they are readily accessible and may be removed by adequate surgical procedures. Of at least equal importance in the early diagnosis of these tumors is the difficulty of always differentiating between a benign tumor and one in which malignant transformation has occurred. Stewart,²⁵ as the result of his observations in the course of 11,000 necropsies performed at the Leeds General Infirmary, has presented quite conclusive evidence that certain tumors of epithelial origin in the stomach undergo malignant transformation, and

in some instances are associated with carcinoma. Judd and Hoerner⁸ stated that in two of their cases of benign tumor, malignant transformation had occurred. Stewart²⁵ has stated that there is a certain amount of evidence to show that sarcomatous metamorphosis may occasionally occur in simple leiomyoma of the alimentary tract just as in uterine fibroids. Of interest in this connection is the discussion by Melnick¹⁴ of metastasizing leiomyoma of the stomach in which he reports a case of benign ulcerated leiomyoma of the stomach from



Fig. 6.—Gross specimens of polypoid tumors of the stomach (Case 2).

which the patient had a fatal hemorrhage, and necropsy disclosed a metastatic lesion in the liver which histologically resembled almost exactly the tumor in the stomach. That malignant transformation may occur in a previously benign tumor of the stomach seems exemplified in the following case:

CASE 2.—Mrs. E. M. H., aged seventy years, was referred to me on July 1, 1931, with a diagnosis of multiple polypoid tumors. The patient stated that for approximately thirteen years she had had periods of weakness and anemia. During this

time, she had had mild digestive disturbances intermittently, characterized by gas and indefinite epigastric distress without any particular relationship to food-taking.

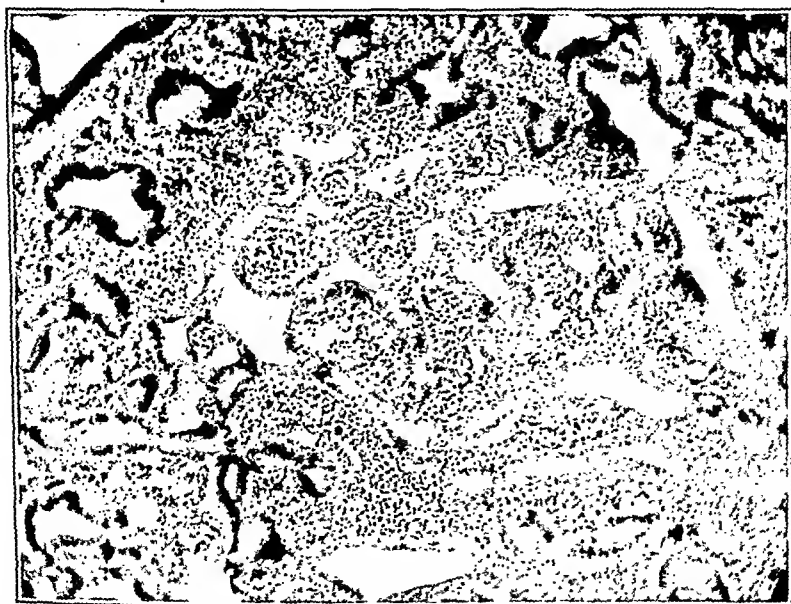


Fig. 7.—Low power of polypoid portion of tumor showing glands and papillary formation (Case 2).

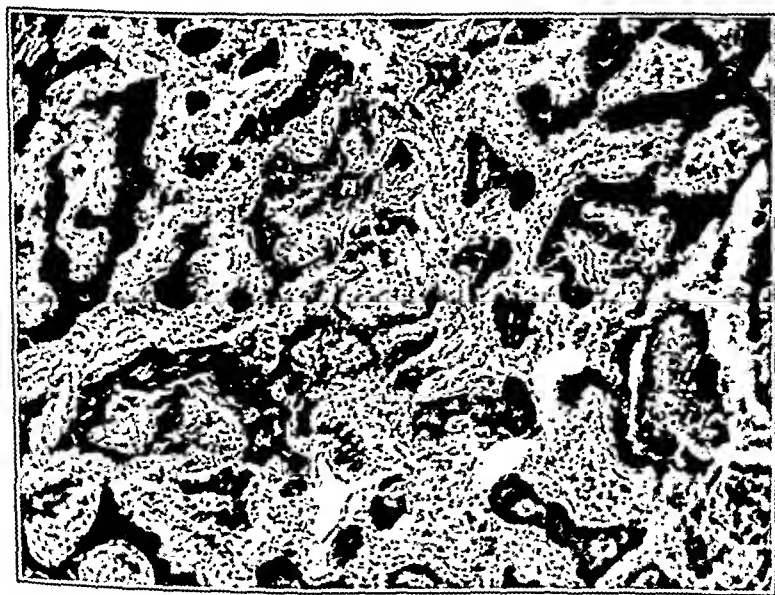


Fig. 8.—Low power of base of polypoid tumor, showing branching nests and cords of neoplastic epithelial cells invading the stomach wall.

During the previous ten years, the patient had been underweight and seldom weighed more than ninety pounds. In April, 1930, fifteen months prior to our consultation, the patient was examined elsewhere, and a diagnosis of pernicious anemia was

in some instances are associated with carcinoma. Judd and Hoerner⁸ stated that in two of their cases of benign tumor, malignant transformation had occurred. Stewart²⁵ has stated that there is a certain amount of evidence to show that sarcomatous metamorphosis may occasionally occur in simple leiomyoma of the alimentary tract just as in uterine fibroids. Of interest in this connection is the discussion by Melnick¹⁴ of metastasizing leiomyoma of the stomach in which he reports a case of benign ulcerated leiomyoma of the stomach from

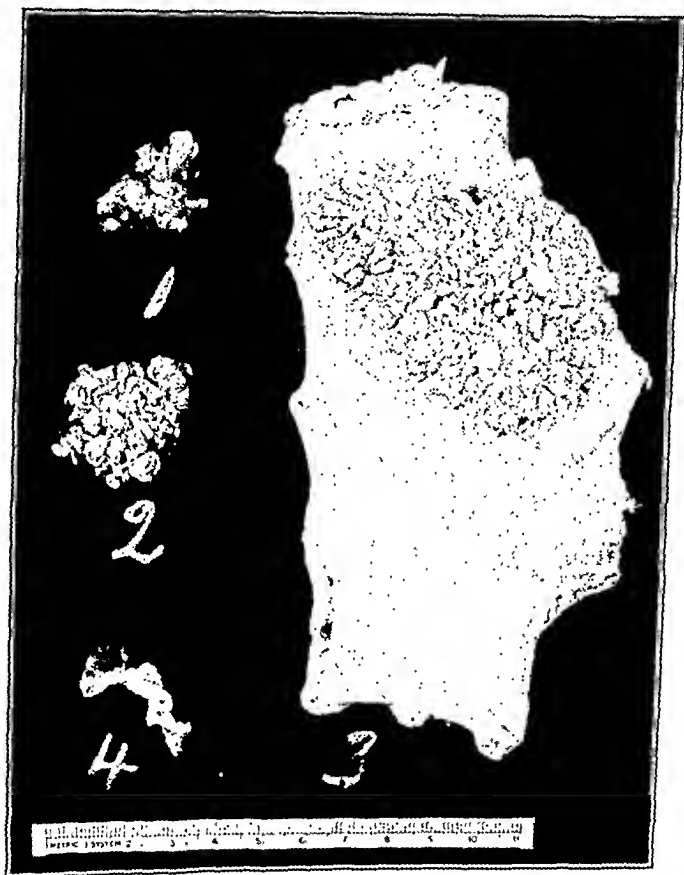


Fig. 6.—Gross specimens of polypoid tumors of the stomach (Case 2).

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CASE 2.—Mrs. E. M. H., aged seventy years, was referred to me on July 1, 1931, with a diagnosis of multiple polypoid tumors. The patient stated that for approximately thirteen years she had had periods of weakness and anemia. During this

mately 60 per cent of the cases which have been operated upon, the tumor was removed by partial gastrectomy, most often by pyloric resection, but in a relatively small number of cases by midgastric sleeve resection. The remainder were removed through local trans-gastric excision.

It seems worthy of emphasis, because of the likelihood of malignant transformation, the difficulty and inability often encountered in differentiating a benign from a malignant tumor, and the hemorrhagic tendency, that all tumors of this character should be operated upon.

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made. Blood was constantly found in the stools at that time, and there was marked anemia. The concentration of the hemoglobin was 37 per cent, and the erythrocytes numbered 1,690,000 in each cubic millimeter of blood. A gastrointestinal study was made at that time, but because of the poor condition of the patient, the usual methods of conducting such a study could not be employed, and no gastrointestinal lesion was visualized. Under treatment for pernicious anemia, the patient improved markedly, and a subsequent roentgenologic study revealed the gastric lesions (Fig. 5).

When the patient was brought to our attention on July 1, 1931, her weight was ninety-eight pounds. The systolic blood pressure was 128, and the diastolic pressure 72. The patient was markedly anemic. General physical examination, however, was essentially negative. The urinalysis was negative. The concentration of the hemoglobin was 39 per cent, the erythrocytes numbered 2,980,000 in each cubic millimeter of blood, and the leucocytes numbered 4,600 with a differential count as follows: neutrophils, 76 per cent; lymphocytes, 22 per cent; eosinophiles, 2 per cent; slight polychromatophilia, slight poikilocytosis; moderate anicytosis, and marked acronia. Because of the poor general condition of the patient, largely due to the anemia, operation was deferred for six weeks, during which time marked improvement in the anemia and general condition of the patient occurred.

The preoperative diagnosis was multiple polypoid tumors of the stomach. Operation: August 15, 1931, at St. Vincent's Hospital. Upon opening the abdomen, several tumors were palpable in the stomach; the largest tumor was nearly 8 cm. in diameter and was situated in the middle third of the stomach attached to the posterior wall. This tumor was removed by median gastric sleeve resection. Three other tumors varying in size from 1 to 3 cm. in diameter were situated in the cardiac third of the stomach and were removed by local excision.

Pathologic report (Dr. E. M. Hall): The specimens consisted of four papillomatous tumors of the stomach (Fig. 6). The largest of these measured 6 by 6 by 3 cm. in diameter, and the others measured 3 by 3 by 1.5 cm., 3 by 2 by 1 cm., and 1 cm. in diameter. They were all similar in that they showed a distinct papillary growth. Many of the stalks were thick and bulbous at the tip. Examination of sections from these tumors showed a very irregular polypoid growth upward of the mucous membrane consisting of villi covered with tall columnar epithelium together with stalklike outgrowths containing acini of variable size (Fig. 7). In none of the four tumors did the newgrowth break through the muscularis mucosae. In two tumors, however, the glandular part had become quite atypical, showing fairly large areas in which the acini were solid and irregular, and the epithelial cells appeared to have taken on malignant change (Fig. 8). The nuclei were larger and many contained large nucleoli. Occasional mitoses were seen. Many lymphocytes and plasma cells were present in the interstitial tissue together with a moderate number of polymorphonuclear leucocytes and eosinophiles. Diagnosis: Polyposis of the stomach with early malignant degeneration.

CONCLUSION

In the majority of the cases in which a tumor was palpable or in which clinical symptoms led to a preoperative diagnosis of tumor of the stomach and surgical exploration, the tumor was situated in an accessible portion of the stomach and was readily removed. It is likewise noteworthy that in many of those instances in which fatal massive hemorrhage had occurred, necropsy revealed the tumor readily accessible to a surgical procedure had it been instituted. In approxi-

CANCER OF THE STOMACH

In cancer of the stomach, there is a large area in which no symptoms are produced by any growth unless there is perforation, hemorrhage, or obstruction. This area comprises the cardiac portion of the stomach and much of the greater curvature. Cancer itself rarely causes pain in the early stages, unless it develops in areas of confinement, as in the bone where the new tissue produces pressure. It is chiefly along the outlet of the stomach, where obstruction may occur, or along the lesser curvature, where interference with the physiologically active motor portion of the stomach may produce mild symptoms, that we can hope for a very early diagnosis. A majority of cases of cancer occur in the right half of the stomach and therefore should lend themselves to an early diagnosis, if there is accurate observation of the first clinical symptoms. The textbook picture of hemorrhage from the stomach, cachexia, a palpable mass, and enlarged lymph nodes in the base of the neck, shows only the terminal stages, and in most instances when these symptoms appear, the outlook is hopeless. There are a few cases, however, in which the cancer is of the funguslike type, a rather large mass with septic symptoms, and yet is comparatively mild in its histologic degree of malignancy. In such instances, even though the patient may appear to be in desperate condition, operation occasionally offers relief, even if it does not cure. The colloid, or so-called mucoid cancers, often belong in this class of cases.

Early diagnosis of cancer of the stomach depends upon the careful consideration of what often appears to be trivial symptoms. While the laboratory diagnosis may be helpful, it is well known that many persons over thirty-five years of age, particularly women, have low acid in the gastric juice and not infrequently complete achlorhydria. Some claim that this is a result of a gastritis, and that this in turn may be the forerunner of cancer. However, the number of cases of cancer compared with those of achlorhydria, or low acid in the gastric juice, is so small as to make this lead of very slight, though not negligible, value. Yet I have seen some very malignant gastric cancers with high acid value in the gastric juice. One of them, Mr. C. G. W., aged thirty-one years, had free hydrochloric acid as high as 90 degrees. He had a lesion in the stomach which resembled very much a large perforating ulcer. A partial gastrectomy was done, removing a portion of the pancreas. He made a satisfactory immediate recovery, but had an extensive recurrence in about six months, and died within a year from the time of operation. This proved to be a type of small cell carcinoma which is unusual, and while the metastases responded at first to irradiation, when the disease began advancing again, irradiation was ineffective.

In another patient, Mr. W. S. B., with advanced gastric carcinoma, there was as much as 77 degrees free hydrochloric acid. In this pa-

SOME OBSERVATIONS ON CANCER OF THE GASTROINTESTINAL TRACT*

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THE challenge of the cancer problem cannot be ignored, when we recall that during the past year more than 140,000 persons in the United States died from cancer, and particularly when we realize that many of these deaths were preventable if the diagnosis of the condition had been made at an early stage and proper treatment had been promptly given. The chief factor in these deaths is cancer of the gastrointestinal tract. Cancer of the stomach causes far more deaths than cancer of any other one organ. Many patients who die of vague conditions and upon whom necropsies are not done doubtless have cancer of the stomach, because, in cities or regions where the percentage of necropsies is high, the death rate from cancer of the stomach is usually also high. The deaths from cancer of the stomach last year may be estimated at a minimum of 35,000 when these facts are considered. In 1933, there were 128,475 deaths from cancer in the United States. Of these, 26,565 were from cancer of the stomach and duodenum, and 19,344 from cancer of the intestines, including the rectum. This makes a total of 45,909. If the deaths from cancer of the pancreas and liver, glands which are adjuvant to the gastrointestinal tract, are added, there are 60,070 deaths, almost half of the total deaths from cancer.

The only satisfactory treatment for cancer of the gastrointestinal tract is excision. In the lower rectum and anus, the application of radiation from radium, radium emanations, or x-rays, is sometimes helpful and may be curative, but above the lower portion of the rectum and anus, radiation as a therapeutic measure has usually but little effect. The problem before us is simple in statement but difficult of execution. It is, first of all, the diagnosis of the lesion in its early stage, and, second, the prompt excision of the diseased tissue. The chief difficulty is an early diagnosis, but another difficulty like unto this is the securing of prompt and efficient treatment in the form of an operation by a surgeon competent to do this work as soon as possible after the diagnosis is made.

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often remittent or intermittent in its symptoms, just as an ulcer would be, and the fact that the symptoms disappear entirely is by no means an assurance that the lesion is a benign peptic ulcer.

If any person, particularly a man within the so-called "tropic of cancer," that is, over thirty-five years of age, has symptoms of "stomach trouble," the case should not be lightly dismissed. If after a gastric analysis and a thorough study by the physician, the cause of the complaint cannot be definitely determined, the patient should be referred to a competent roentgenologist, one who has experience and skill in making diagnoses of gastrointestinal lesions. Not infrequently fluoroscopic observations are more valuable than the plates, and these two methods should be interpreted together. It must be recalled, however, that, even when a lesion with slight symptoms is demonstrated by x-ray, it may already be well advanced. The more recent improvements in roentgenologic diagnosis, in which the affected segment of the stomach will show changes in the pattern of the mucosa or in peristalsis even before a filling defect has become noticeable, will doubtless be more helpful in the future.

An ulcer or any lesion of the stomach that is suspected of being carcinoma should not be allowed to remain too long. If it seems probable that it is a peptic ulcer, medical treatment is justifiable for two or three weeks, when the examination should be repeated, and, if the diagnosis still is in doubt, the patient should be operated upon. William Gerry Morgan, a medical gastroenterologist, goes so far as to say that all gastric ulcers are surgical conditions from the beginning. While I am not so radical as that, I believe that more cases of cancer could be saved if his doctrine were followed than if there is an indeterminate delay.

Gastric peptic ulcer is, of course, quite different from ulcer of the duodenum, in which operation may never be indicated unless there is hemorrhage, perforation, or obstruction. Cancer rarely develops from an ulcer of the duodenum, though there are a few cases reported in which this has occurred.

CANCER OF THE SMALL BOWEL.

Cancer of the ampulla of Vater is infrequent, but it is always formidable. Irvin Abell has treated some of these cases by opening the duodenum and implanting radium. Radium emanations are preferable, but if the "seeds" are not available, radium in needles may be used, attached to linen threads brought up through the esophagus by a stomach tube so that the needles can be removed at the proper time.

Recently Allen O. Whipple and his associates have devised an operation for excision of the duodenum for cancer of the head of the pancreas. In either of these lesions, practically the same operation must be done because of the intimate relationship of the ampulla of Vater

tient the cancer was very extensive, and there was a small metastasis in the liver. There was bleeding from an artery in the cancerous area, and the portion of the stomach involved in the cancer could be removed. A partial gastrectomy was done, and the patient did well for a while, but died of peritonitis six days after the operation.

While such cases are unusual, we should bear in mind the fact that cancer of the stomach may occur with normal or high hydrochloric acid values in the gastric juice.

The diagnosis of cancer in the cardiac end of the stomach, though difficult, may be made by careful interpretation of symptoms and a thorough roentgenologic study. I recall a case in Atlanta in which a brilliant diagnosis of a lesion in the cardiac portion of the stomach was made by T. C. Johnson and J. L. Campbell. Johnson demonstrated a filling defect which I believed was cancerous. An operation was advised, but was postponed by the patient for several months. When it was done elsewhere, it was found to be too late. Postponing an operation for cancer in order to settle business affairs is often fatal. The growth of cancer does not wait for such things. As soon as the diagnosis can be reasonably well made, at least an exploratory operation should be done.

The ratio of the incidence of gastric cancer following peptic ulcer is a much disputed point. That it does occur in some cases is acknowledged by all. Holmes, roentgenologist of the Massachusetts General Hospital, Boston, claims that many ulcers about the pyloric end of the stomach are potentially cancerous and, in common with most roentgenologists and clinicians, he believes that probably all ulcers that can be demonstrated roentgenologically on the greater curvature of the stomach are malignant. This rule, too, may be subject to exceptions. I have had one patient with ulcer on the greater curvature that was apparently not malignant. This was a recurrent lesion after a partial gastrectomy for a posterior perforating ulcer at the pyloric ring. It would, however, be safer to regard all ulcers in the greater curvature as malignant. Such simple symptoms of indigestion as loss of appetite, so-called waterbrash and heartburn, with slight discomfort in the region of the stomach, occasionally, though not usually, coming on somewhat like the hunger pains of peptic ulcer, may be symptoms of cancer. Except when a polyp is present, bleeding from gastric cancer is uncommon as compared with peptic ulcer. Almost one-half of all gastric cancers do not ulcerate. Gaither has summed up in an excellent article an analysis of 245 cases of cancer of the stomach demonstrated by operation and treated at Johns Hopkins Hospital during a period of ten years. He emphasized the fact that not only is the clinical course of gastric cancer as described in the textbooks often erroneous, but that many of the statements found there are absolutely misleading and may actually prevent an early diagnosis. Thus, cancer of the stomach is

products, very closely simulating cancer. An endometrioma of the sigmoid and upper rectum is occasionally found. Polyps are not uncommon.

On the right side, operation may be done in one or in two stages. In the first stage, the ileum is divided with the cautery between forceps and united to the transverse colon end-to-side. If its mesentery is free, the cecum and ascending colon can then be excised at the same operation, but if there are many adhesions, it will be best to do this subsequently.

In tumors of the left colon down to the rectum, in my opinion, a three-stage operation should always be done. In the first operation, a cecostomy is made with a glass rod under the ascending colon, so as to shunt all of the fecal matter through this cecostomy opening. About two weeks later, the cancer is resected, with union of the colon by the end-to-end method or, if the patient is fat and the bowel adherent, a modified Mikuliez operation can be done. In this latter procedure, the loop is brought onto the surface of the abdomen, the two limbs of the loop are sutured together, and then the affected portion of the bowel is doubly clamped at each end and severed with the cautery. The clamps are left on for some days, as the cecostomy prevents obstruction. The spur is later crushed, and a lumen is established. If, however, the affected segment of bowel is freely movable, an end-to-end union may be done. It must be recalled that in the Mikuliez type of operation, the excision often cannot be quite so radical as in resection with end-to-end union. I have seen a recurrence of the cancer in the ends of the two stumps that followed a Mikuliez type of operation.

Cancer of the rectosigmoid junction and of the upper rectum can now be removed radically, and an end-to-end union made by suturing the stump of the sigmoid to the stump of the rectum. Two long guy sutures of linen are placed in the posterior wall of each stump, after rotating the upper stump so that the peritoneal surface will be posterior. By shoving down the upper stump to the lower stump as the guy sutures are tied, contact is made between the posterior margins of each stump, and they are sutured together, and then the anterior portion is sutured. The patient is in the Trendelenburg position. This, of course, presupposes that the cecostomy has been done at least two weeks before and that the colon is empty. The block dissection of the sigmoid and upper rectum is just as thorough as though the whole rectum were to be extirpated. The usual technic employed in these cases has been to make an artificial anus. If, however, the continuity of the bowel can be established after excision of the rectosigmoid junction and the upper rectum, and the chances of cure are not sacrificed, it would seem to be a more desirable procedure. I have done this in several cases in the last three years.

In cancer of the rectum, I prefer a one-stage operation of the abdominoperineal type, based on the Miles procedure. The abdominal

with the structures around the pancreatic duct and the head of the pancreas. In this operation, which he has done on four cases, he makes use of the fact known to physiologists for some time, that the pancreatic duct may be safely ligated in dogs. Physiologists have shown that complete occlusion of the pancreatic duct can be done without seriously impairing health. This greatly simplifies the operation, which Whipple does in two stages. In the first stage, the gallbladder is anastomosed to the stomach and a gastroenterostomy is established. Thus, the jaundice is permitted to clear up, and the patient becomes better nourished. In the second stage, the duodenum and the head of the pancreas are excised. By this technic, cancer of the ampulla of Vater or of the head of the pancreas has been brought into the field of reasonable endeavors for its cure; formerly excision of the duodenum and the head of the pancreas had been done chiefly as an experimental procedure in dogs.

Cancer of the small intestine, while uncommon, arises sufficiently often to demand our attention. It is often difficult to diagnose. It is usually either lymphosarcoma or of the carcinoid variety. Several cases of this latter type have been reported, in some of which there is metastasis from the growth. Usually, however, this carcinoid, or argentaffine, cancer remains local, is not extremely malignant, and is readily cured by resection. This is the type of cancer found in the appendix, occurring as a small orange-yellow growth near the tip of the appendix. When removed by the technic of ordinary appendectomy, there is often no further trouble.

CANCER OF THE LARGE BOWEL

Cancer of the large bowel is a common type and should be considered in three different groups: first, cancer of the right large bowel; second, cancer of the left large bowel down to the upper rectum; and, third, cancer of the distal two-thirds of the rectum.

In the right large bowel cancer is usually different from cancer in the left. In the right side, it is often of the fungous type and ulcerating. Not infrequently, because of the saprophytic toxin, one of its early signs is a secondary anemia that may very closely simulate a primary anemia. The patient may have marked hemorrhages, and pain is often a fairly early symptom, from the involvement of the adjacent parietal peritoneum. This involvement does not necessarily indicate that the cancer itself has invaded the peritoneum, but rather that the congestion which accompanies the necrotic mass extends to the peritoneum, and that the saprophytic bacteria may have produced a local peritonitis.

In cancer of the left half of the bowel, one of the earliest symptoms may be obstruction. Here, too, other lesions are found, such as diverticula, which may rupture or may infiltrate the bowel with inflammatory

early cancer of the rectum in which the mucous membrane was freely movable, the lesion was excised with the cautery. In a few months the cancer returned, and the condition was hopeless. I am confident that if I had done a radical operation in that patient at first, she would have been permanently cured.

Obvious cancer of the mouth or cheeks frequently can be excised with the cautery, with reasonable expectation of cure. However, in these cases, there should be a frozen section made at the time of operation, and, if a higher grade of malignancy than expected is demonstrated, a more radical operation accompanied by irradiation either in the form of radon, radium metal, or x-ray, or combinations of these procedures, should be applied. As we have learned, however, cancer of the gastrointestinal tract is to a very great extent radioresistant, and radical surgery must be done when the growth is first attacked, because recurrences are usually hopeless.

CONCLUSIONS

By carefully observing and analyzing apparently trivial symptoms of so-called indigestion or dyspepsia, of bleeding or discharge from the bowel, or of changes in the habits of the bowels, a diagnosis of malignancy of the gastrointestinal tract may be suggested in its incipency, to be confirmed or disproved by roentgenologic examination. An early cancer of the stomach or bowel properly excised should give a high percentage of cures. Even late cases may sometimes be relieved and occasionally cured.

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portion is done first, and the upper stump is drawn through a stab wound to the left of the incision. Then the lower stump is pushed down, a peritoneal diaphragm over the pelvis is sutured, and the wound is closed. The patient is placed in the dorsal position or in the lateral position, and the excision is completed from below. One of the chief objections against this operation is the danger of shock. However, if an intravenous cannula is inserted at the beginning of the operation, and five per cent dextrose in Ringer's solution is permitted to run in at the rate of 150 to 200 c.c. an hour, or more rapidly if indicated, the operation can usually be completed with but little or no shock. These patients should have at least one donor matched up and ready for transfusion of blood at the end of the operation, and, if the intravenous dextrose in Ringer's solution does not maintain the blood pressure satisfactorily, a transfusion should be given at once. In this way the danger of shock can be to a large extent averted. When cancerous tissue is handled or manipulated, it is much better to have it removed at the same operation. In the three-stage operation mentioned for the left colon, the cancerous tissue is not manipulated, except when the actual resection is done. The stages are for affording rest to the bowel and for making healing more prompt and peritonitis less formidable.

In resection of the colon, we usually apply intraperitoneally the Steinberg colibaetragen. Formerly this was injected several days before the operation, but now Steinberg has produced a product which reaches its maximum of protection in a few hours, and may be placed in the peritoneal cavity during the operation and will be effective.

Cancer of the rectum is comparatively common. It is truly pathetic to see how many cases of cancer of the rectum are permitted to go to a late stage, when a simple digital examination might detect the disease in its incipency. A patient who has bleeding from the rectum, or symptoms of discharge or anal discomfort should always be examined, at least digitally; this is best done with the fingers encased in a rubber glove, so permitting a deeper examination than with a finger cot. This may be followed by a proctoscopic examination, but a vast majority of cancers in the lower rectum can be definitely detected by a simple, thorough digital examination, whereas merely prescribing a salve or suppositories without such an examination may lead to disaster.

Patients with mild, or low grade, or early cancer of the rectum are those in whom a cure will almost certainly be obtained by a radical operation, and the temptation to do something conservative is not infrequently fatal. Of course, if there is a polyp that is suspected of being malignant, it can be excised with the cautery or with the endotherm, but an ulcerating cancer, even though it does not go through the whole wall of the bowel, demands radical operation. By doing a radical operation in an early cancer, we can almost assure a cure. I recall a bitter experience of my own several years ago, when, in a patient who had an

healthy vascular tissue. For this reason, it is sometimes advisable to do a plastic operation and remove scar tissue over superficial bones or adherent to bone some weeks before undertaking the grafting operation. Likewise, at the time of the operation, scar tissue around the

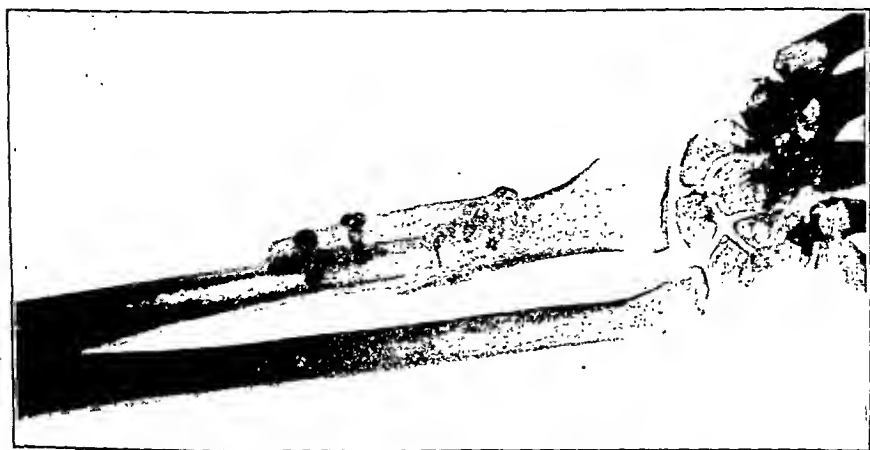


Fig. 1.—Bone graft for nonunion of the radius, three months postoperative, union firm. No further trouble.

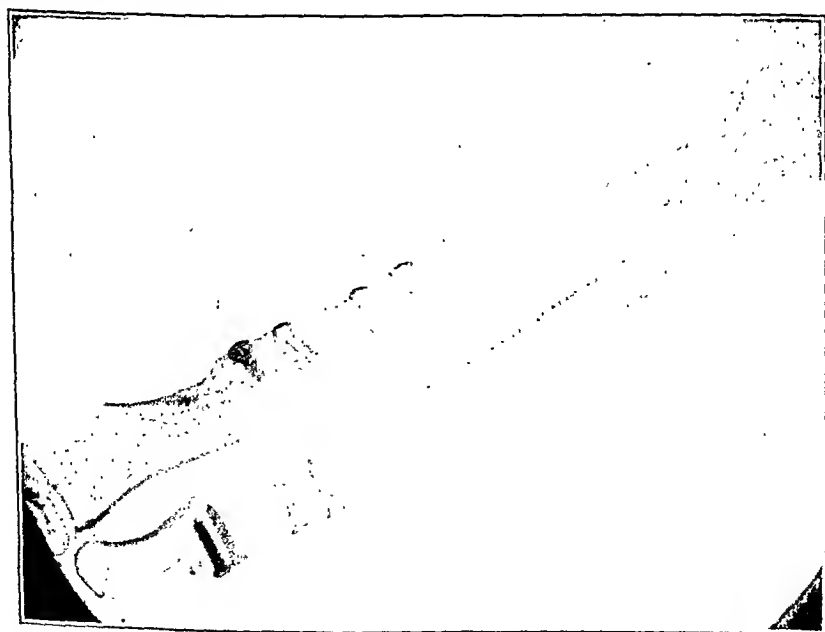


Fig. 2.—Bone grafts for both bones of the forearm, six months postoperative. Two wood screws and six selftapping screws were used. Union firm in eight weeks.

ends of the bones should be removed back to good vascular tissue, and the marrow canal of each fragment should be opened, and if the bone is eburnated, numerous small holes should be bored into the ends of the fragments.

TREATMENT OF NONUNION OF FRACTURES WITH BONE GRAFTS FIXED BY METAL SCREWS

J. ALBERT KEY, M.D., ST. LOUIS, MO.

(From the Department of Surgery of the Washington University School of Medicine)

WHEN a long bone has failed to unite and further treatment is demanded, the surgeon usually must decide on some type of operative interference. At the present time, the methods principally used are drilling of the fragments, either with or without free exposure of the site of nonunion, overlapping, or cut stepping the fragments and fixing them together with screws or wires, or inserting some form of bone graft at the site of the nonunion. During the past five years, I have consistently used a large autogenous slab of bone which has been fixed to both fragments by metal screws and wish to report the method in detail.

The principal types of bone graft now in use are the intramedullary peg, with or without fixation in one fragment to prevent its sliding upward or downward in the medullary canal; the massive diamond-shaped graft, the points of which are inserted into each fragment and wedged in position so that it is a modified intramedullary peg bridging a gap; the onlay graft which Campbell fixes with autogenous pegs and which Henderson fixes with beef bone screws; the inlay graft, usually a sliding graft which is sometimes dovetailed into position, sometimes fixed with wires, sutures, or pegs; the multiple barrel stave grafts of Steele which may be fixed with a suture or wire; and the osteoperiosteal grafts of Ollier and Delagenier, which are usually laid across the site of the nonunion. Finally, there is the delayed inlay graft of Brooks in which the graft is cut and transplanted two weeks later after osteogenesis has started. In most instances, surgeons at the present time fill in any dead space between the bone ends with autogenous bone fragments.

When considering operation in an effort to obtain union in bones which have, for some reason, failed to unite, the following requirements must be met:

1. *Asepsis*.—No bone graft should be undertaken in the presence of infection; in operating upon bones which are or have been infected, it is advisable to first clear up any local infection and wait at least six months after the wound has been permanently healed before attempting to place a graft across the site of the nonunion.

2. *Blood Supply*.—It is not only important that the bone ends receive adequate blood supply, but also that the area next to the graft be

grafts of Henderson and Campbell are, I believe, the best type for routine use in nonunion of long bones, but my experience with the beef bone screws has been that they not infrequently jam and either break or have to be cut off and are quite difficult to insert. Furthermore, both the graft and the bone fragments have to be threaded, and



Fig. 1.—Old fracture of the humerus with nonunion and free fragment.

when this is done, the screw does not press the graft down upon the bone. I have not used the autogenous bone pegs of Campbell, but I do not believe that it would be possible for me to fix a graft as firmly with the pegs as I can with the beef bone screws, and I know that I cannot fix it as firmly with the beef bone screws as I can with metal

3. *Apposition of Bone Ends.*—All sear or fibrous tissue between the ends of the bone should be excised and, as a rule, the ends of the fragments should be excised for a short distance. If possible, the ends of the fragments should be placed in contact. If not possible, the space between them should be filled with bone.

4. *Osteogenic Material.*—The fate of an autogenous bone graft is not definitely known. Some believe that the graft lives and persists; some believe that it dies and may be replaced by living bone; and some, of which I am one, believe that the major portion of the graft dies, but that some of its surface cells live and may proliferate and form new bone. Regardless of which of the above views is correct, it is generally conceded that in operating for nonunion, an autogenous bone graft operation is more likely to result in union than is any other type of operation. Consequently, I believe that autogenous grafts should

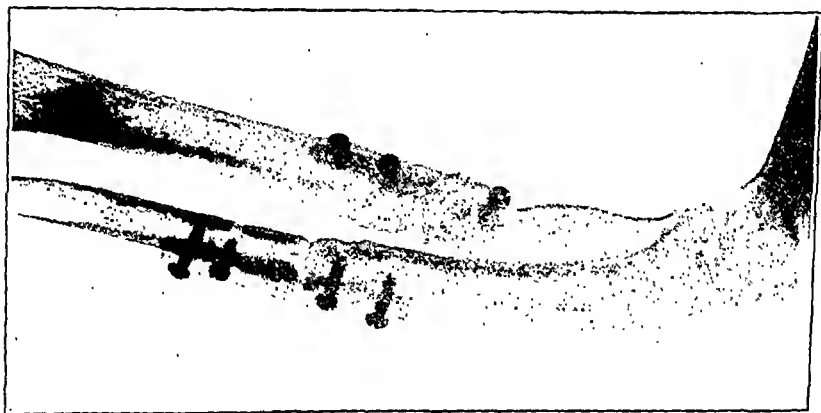


Fig. 3.—Bone grafts for nonunion of both bones of the forearm. Only one screw in proximal fragment of radius because of proximity to posterior interosseous nerve. Union firm in nine weeks.

be used wherever a bone grafting operation is necessary and that not only should the graft be autogenous, but it should be reinforced by bone chips and osteoperiosteal grafts.

5. *Immobilization.*—When possible the fragments should be completely immobilized by internal fixation as well as by external fixation, because splints and plaster casts do not completely immobilize the fragments, and even a small amount of movement may hinder union.

The objections to the various methods of bone grafting which are in current use are the following: The intramedullary peg and massive bone graft tend to block the medullary canal and offer incomplete fixation. The barrel stave grafts and osteoperiosteal grafts give very little fixation. The inlay grafts, in my experience, do not afford very firm immobilization and will not stand much strain. The massive onlay

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screws. I have used the delayed inlay grafts of Brooks, but did not find that this method offered any especial advantage. It increases the danger of infection.

TECHNIC OF OPERATION

The skin of the leg to be operated upon and the skin of the leg from which the graft is to be removed, usually a normal tibia, are given a forty-eight-hour sterile preparation before the operation. The operation is done under general anesthesia and usually without a tourniquet. The site of the nonunion is adequately exposed, but not always by the most direct route. For instance, in operating upon the tibia, the incision is made on the anterolateral aspect of the leg, and the graft is placed on the lateral surface of the bone beneath the muscle. In other words, the incision is so planned that the graft and the area of nonunion will be covered by an adequate layer of healthy tissue and will receive an adequate blood supply.

When the site of the nonunion is exposed, the periosteum is split and stripped back from the exposed surface of each fragment over a distance sufficient to allow for the length of the graft. The scar tissue or cartilage, or both, between the ends of the bones is excised—usually by cutting off the ends of each fragment with an osteotome. Then, with a one-fourth inch or larger drill, the marrow canal of each fragment is completely opened, and the ends of the fragments are squared off if possible. If not, all of the scar tissue between them is removed down to hard bone. Usually the ends of the fragments are eburnated, and with a small drill (one-eighth of an inch or less), several holes are drilled through each cortex of each fragment in various directions. The bones are then placed in the position in which it is expected to secure union. If the ends can be approximated, this is done and the length of the graft desired is estimated.

Then the wound is covered with a towel, and the normal tibia is exposed by a long straight incision over the anteromesial (subcutaneous) surface, and the graft is outlined with a knife. I usually do not strip the periosteum from the bone. I have not seen, however, that this made any particular difference in the result. After the graft has been outlined, the positions of the screws are estimated, and the holes are drilled in the graft and countersunk before the graft is removed. I usually use three screws in each fragment for the femur or tibia or humerus, and two screws in each fragment for the forearm bones. If the site of nonunion is unusually close to a joint, however, and one of the fragments is short, there may be room for only one or two screws in this fragment. The holes drilled in the graft for the screws are slightly larger than the screws to be used and permit the screw to slip through the graft without binding. After the holes have been drilled they are countersunk for a short distance in order to permit the screwheads to lie almost flush with the surface of the graft. The

countersinking also tends to prevent the screws from splitting the graft as they are tightened, and as a further guard against this, the

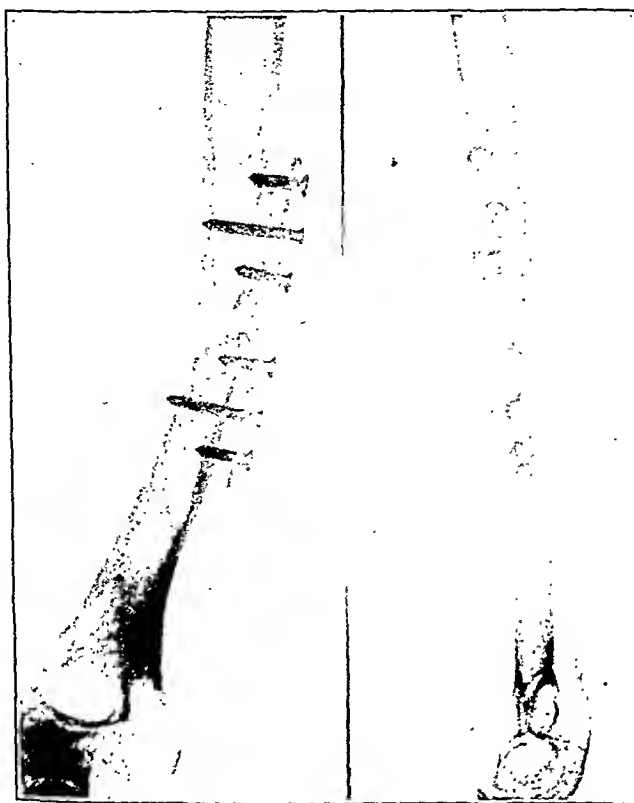


Fig. 5.—Anteroposterior and lateral view of the preceding fracture after grafting. Slight angulation of lower fragment. The loose eburnated fragment was removed, and union was firm in eight weeks.

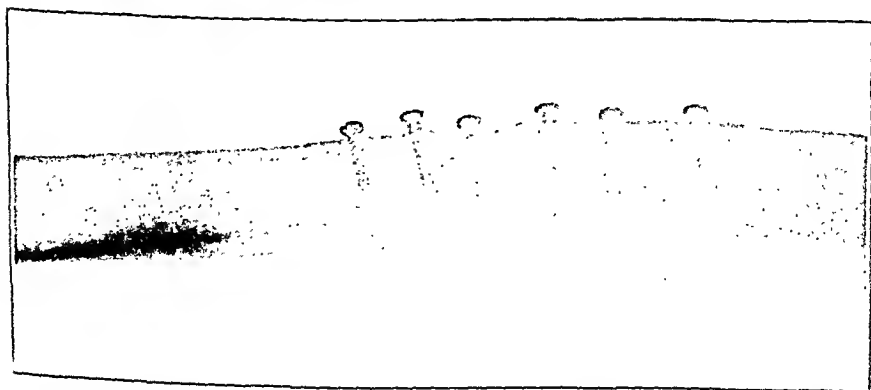


Fig. 6.—Bone graft for nonunion of the femur. Union firm in three months.

screwholes are not placed in a straight line. Then the graft is cut along the margins outlined, usually with a motor saw, and is removed with a thin osteotome. Usually the ends are beveled as it is cut.

There is some danger in removing the graft after the screwholes have been bored, because it is possible to fracture the graft if much force is exerted in prying it loose. This has happened to me on one occasion, and as a result I used a shorter graft than I would have done had it remained intact. If a motor saw is not available or if the

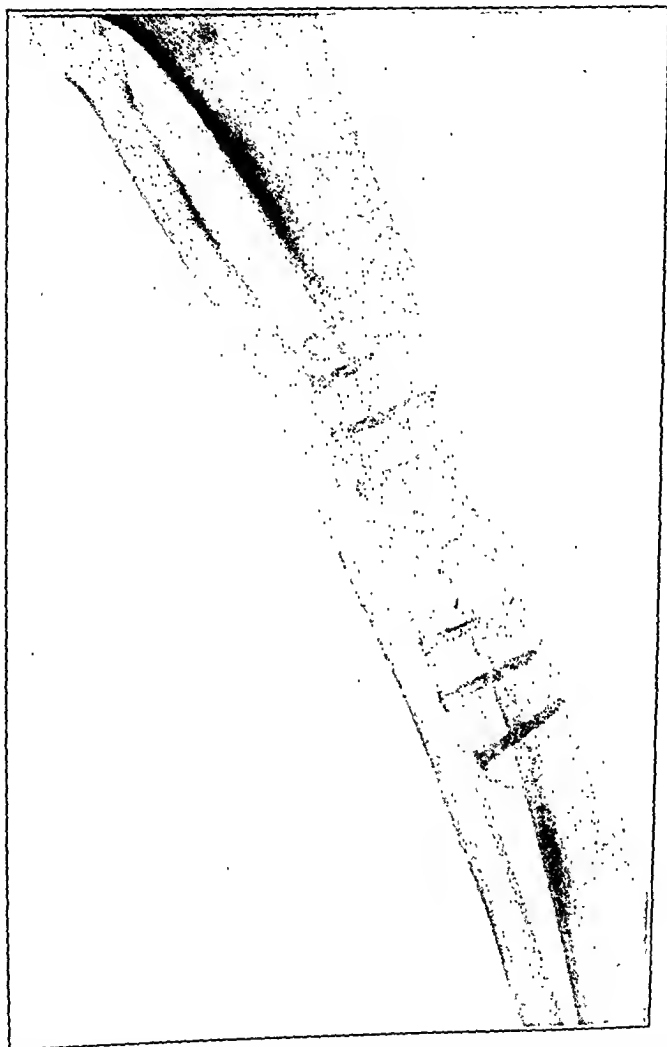


Fig. 7.—Old infected compound fracture of the tibia with nonunion. Saucerization operation and extensive scar excised six months after healing, and one month later bone graft operation done. Space between fragments filled with bone chips. Union firm six months postoperative.

operator prefers, the graft can be removed by boring multiple small drill holes along the edges and then uniting them by cutting the intervening bone with a thin osteotome. This is more tedious, but is said to result in a more viable graft. Personally, I have not found that it

makes any difference, but if this method is used, I believe that it would be wiser to wait until after the graft is removed before boring the holes for the screws. Otherwise, it is apt to be broken during the removal. After the graft is cut, several small osteoperiosteal grafts are cut from the tibia, and also bone chips or cancellous bone fragments are removed if it is necessary to fill in a gap between the fragments. The wound in the leg is sutured immediately, usually by an

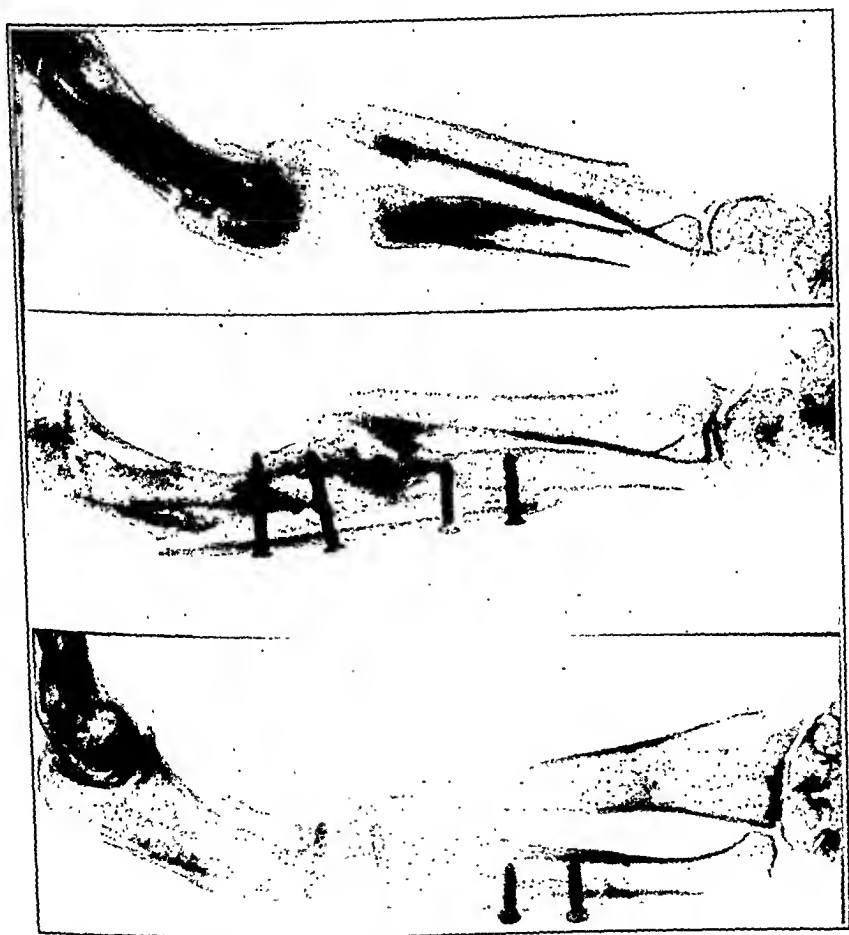


Fig. 8.—Old infected fracture of both bones of the forearm with nonunion. Saucerization operation, then bone graft six months after healing. Lower figures show graft one and one-half years after operation. Synostosis not disturbed.

assistant, and a small rubber tissue drain is left in the wound for twenty-four hours.

The cancellous bone on the medullary side of the graft is removed if it protrudes unduly. Otherwise, the fatty marrow is wiped off with a sponge. The graft is now laid across the fragments at the site of the nonunion in the desired position, and if necessary, the sides of the fragments are flattened with an osteotome in order that the graft may

fit snugly against them. With the graft in position against one fragment, the graft and the end of the bone are grasped with a pair of lion-jawed or other bone-holding forceps; and with a drill smaller than the screw, a hole is drilled through each drill hole in the graft and through the cortex of the fragment, and the steel screws are driven home. I use the standard vanadium steel selftapping screw of Sherman, and for the smaller bones I use two short screws reaching only through the proximal cortex; for larger bones I use one long and two short screws in each fragment, the long screw extending through to the opposite cortex. These screws, if placed in a drill hole which is smaller than the screw, will cut a deep thread and will bind the graft very firmly to the bone, provided the fragments at the site of the nonunion are not too atrophied. All of the screws are driven home in one fragment, and then the other fragment, usually the distal one, is aligned and placed in the position in which it is desired to secure union; with the bone-holding forceps, this fragment and the graft are grasped, and two or three holes, as indicated, are drilled with a drill smaller than the screws in the cortex of the second fragment; and the screws are driven home as before without changing the position.

After the graft is in place, any space remaining between the ends of the bones is packed with bone chips or cancellous bone which has been removed from the tibia at the time of the removal of the graft. The thin osteoperiosteal grafts which were removed from the tibia are placed on either side of the bone to cross the line of nonunion. Then the wound is closed in layers without drainage, and a plaster of Paris cast is applied.

For the femur, I use a single spica cast, a cylinder cast for bones of the leg, a cast extending from the upper arm to the knuckles for bones of the forearm, and a long plaster mold extending from over the shoulder down the back of the arm and down the flexed forearm to the wrist for the humerus.

The plaster cast is removed when it is felt that union is sufficient to warrant it. For bones of the forearm and the humerus, it is removed at the end of six to eight weeks, and for the tibia and femur, at the end of eight to twelve weeks. Where there has been a dead space or gap between the fragments, it is necessary to continue the immobilization longer than in instances where direct apposition of the bone ends has been possible.

COMMENT

The principal objection to the method is that it involves the use of metal in the tissues. There is no question but that nonabsorbable material should not be used if something else can be found which will do the work and do it as well. On the other hand, unless the metal is

subcutaneous, it has been my experience that if union occurs, the metal may remain in the bone indefinitely without causing trouble. In none of the patients upon whom I have operated by the above technic have the screws caused any trouble—this, in spite of the fact that in two of the cases (Figs. 7 and 8), the screws were placed in bone which had been infected over a long period of time. Personally, I would rather use stainless steel than vanadium steel, because I think it causes less reaction in the tissues, and I am now experimenting with selftapping screws made with stainless steel, but as yet they are not on the market.

I find that Bruce Gill¹ reported four cases of nonunion of bones of the forearm in which he immobilized his bone graft with metal screws. In Gill's cases, he split the shaft of the bone and slid half of it down across the gap to use as his graft and then fastened the two halves together with short metal screws. Apparently in his cases the metal did no harm, as all four united without complications. Consequently, I do not think that the use of the metal is a serious objection, because in my hands it makes the operation so much easier to perform and gives so much better immobilization than I have been able to obtain with any absorbable material.

The second serious objection is that selftapping screws, or any other type of screw, will not hold firmly in very atrophic bone, and if the fragments are very atrophic, it will be necessary to supplant the screws with some other form of fixation. For this I would be inclined to use stainless steel wire around the graft and around each fragment in addition to the screws. However, I have not operated upon a case of this type by this method.

The method has the advantages that the operation can be done without resorting to special instruments; it can be used on almost any type of nonunion, even in those instances where only a short upper fragment is available; and that the convalescence is shortened, and union tends to occur promptly. I believe that the promptness of the union is due largely to the very firm internal fixation which is obtained.

In all of the patients upon whom I have operated by this method, union has occurred promptly, and in none of them have there been any complications. The series is not large, and, of course, as more cases are operated upon, I shall expect to have an occasional failure, but I believe that, other things being equal, the failures will be fewer than with any other method with which I am familiar.*

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*Since this article was submitted, I have seen a paper by G. E. Haggart and M. Peelen (*New England J. Med.* 214: 815-824, 1936) in which a technic similar to that described here was used in the treatment of fractures of the humerus.

HIP JOINT FUSION*

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IT IS difficult to select a title for the few remarks I wish to make, because my object is to describe a method of fusion for the hip joint, fashioned to meet the requirements of a small but perhaps broadening group of hip disabilities. This group, soliciting help from the general surgeon, and often passed over by him as representing end-results which cannot be bettered by operation, includes the following:

A. Residual deformity in adults with hip dislocation following suppurative coxitis or epiphysitis, which may have occurred years before consulting the surgeon.

B. Painful subluxation or luxation of the hip, caused by trauma or disease, never reduced or irreducible except by operation, accompanied at times by fracture of the acetabulum or of the femur.

C. Unilateral, congenital hip dislocation with maximal shortening in adults, where a stable, fixed hip may be required by the patient's occupation and where a shelf operation alone, with possible retention of hip motion, is neither feasible nor desired.

The complaint, common to these patients, is the long-standing or painful displacement of the femur from its normal relationship with the acetabulum, with or without loss or absorption of the caput femoris. The hips are usually displaced by trauma or disease, and the patients present shortening of the leg, claudication, telescoping, or loss of the head of the femur, and in some instances damage of the acetabulum. There are present, also, varying degrees of pain and tenderness, enhanced by use, along with diminished function which lessens earning capacity or individual happiness. All results from tuberculous coxitis are excluded. Both the surgeon and patient must come to the conclusion that a bony fusion of the upper end of the femur to the pelvis will promise stability, overcome pain, and lead to greater utility in weight-bearing at work or in play. Any preexisting inflammation must be long quiescent.

The two objectives sought by the surgeon are: first, to regain as much of the lost leg length as possible; and second, to hold this gain of length while a bony fusion, in a favorable relationship of femur to pelvis, is obtained.

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The mechanical difficulties to overcome are that the dislocation present cannot be reduced and a full length of the limb cannot be obtained. It is not feasible to attempt to pull the leg out to greater length and to hold it there by embedded skeletal traction until some type of shelf or ordinary extraarticular fusion operation becomes strong enough to hold the gained length. The acetabulum cannot be deepened and re-shaped for the introduction of the denuded head of the femur, because the head cannot be pulled down far enough to enter the remodeled acetabulum.

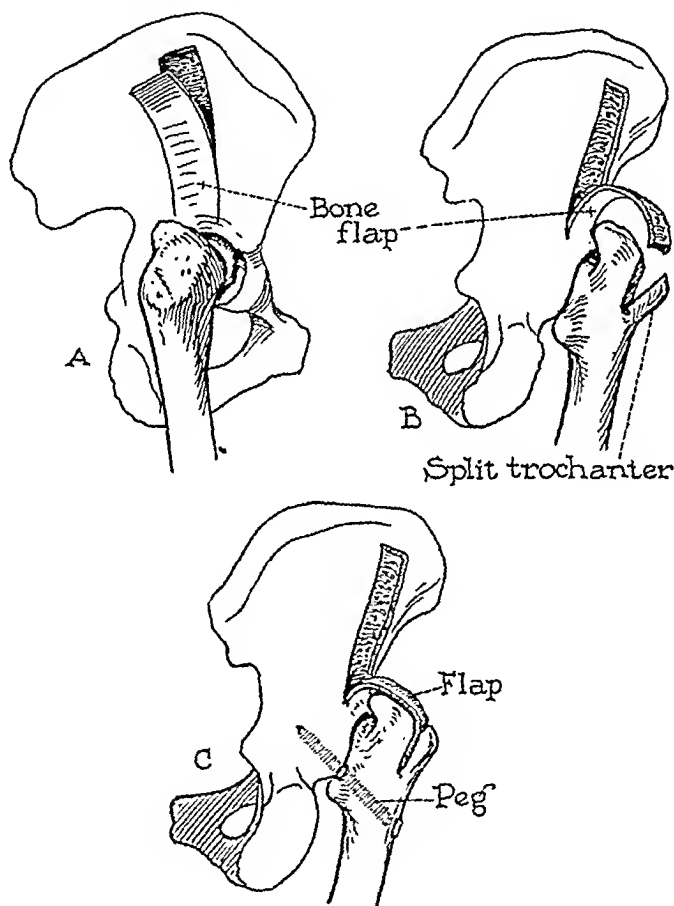


Fig. 1.—Schematic outline drawing of shelf operation for hip joint fusion, aided by bone peg fixation. A, Flap of ilium outlined and turned down from the ilium after surface of neck of femur and ilium have been freshened with a chisel. The drawing represents the femur pulled down farther than it is possible to do in dislocated hip joints selected for this procedure. B, Trochanter split out and ready to receive the bent-down bone shelf, according to Wilson's method. This bone is to act as a source of osteogenic activity and may be aided by fragments of cancellous bone or osteoperiosteal grafts from the exposed ilium, packed under and around the freshened neck of femur and ilium. C, Bone peg driven obliquely through sub-trochanteric portion of femur well into the ilium. The drawing fails to show femur in slight abduction, as it should. A deep penetration of the ilium is desirable as this is a fixation agent to hold until the bony shelf above becomes firmly fused and is able to support the femur above. See Figs. 4 and 5.

Operative Procedure.—Skeletal traction, by means of a Steinmann pin, is applied to the shortened, dislocated limb, either through the condylar portion of the femur or the calcaneus. The head of the bed



Fig. 2.—Hip of a woman, thirty years old, with dislocation following acute, suppurative epiphysitis of the neck of the femur in infancy. The displacement upward of the femur was extreme, the false joint painful, the leg adducted and greatly shortened, the head of the femur completely absorbed, acetabulum outlines indistinct, but this side of the pelvis well-developed. She desired a stable, painless hip for working and ambulation.

is lowered, and a continuous traction is applied to the leg to determine how much length may be regained and held comfortably after the hip

fusion. The amount of time required to pull the leg out varies with age, sex, and musculature of the patient; a week of continuous, hearty traction usually suffices. Gained length is observed by roentgenologic examination by portable apparatus while traction is maintained. Extensive destruction of the femoral head or the edge of the acetabulum may facilitate the procedure and aid the operative fusion by permitting

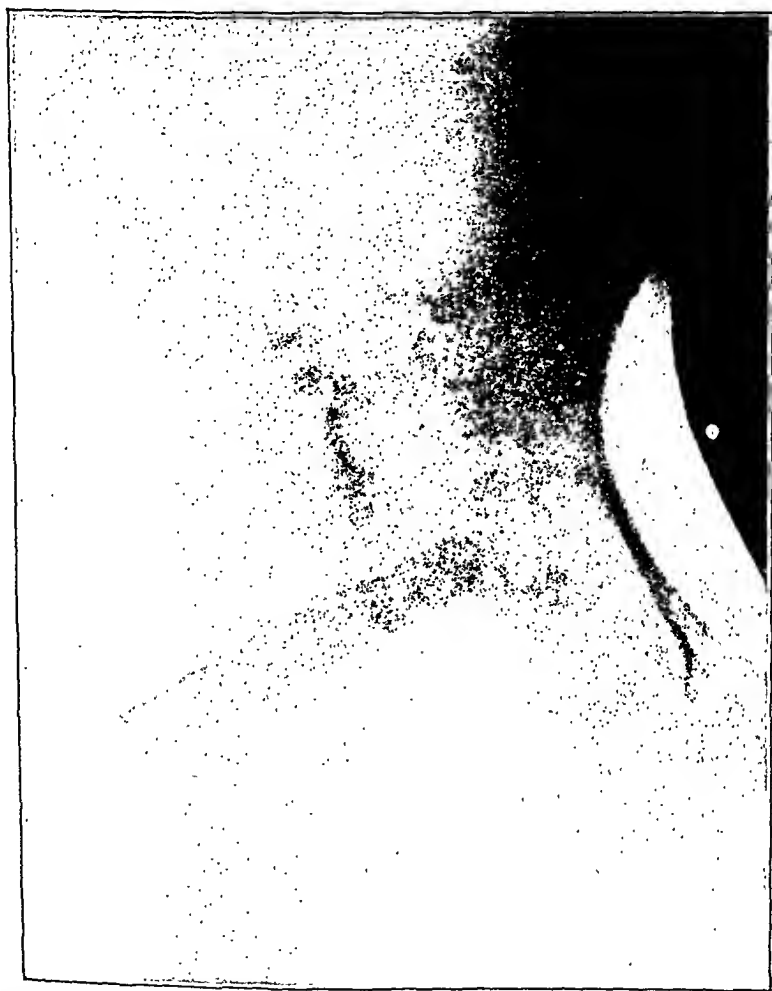


Fig. 3.—The hip shown in Fig. 2, after being drawn down in continuous skeletal traction for nine days, was then operated upon. It is seen that the shelf of bone from the ilium has here been cut and turned down into the trochanter. The reamer is now inserted in the trochanteric portion of the femur as the patient lies on the Hawley table, leg in strong traction. Considerable length of leg has been gained over Fig. 1. The position of the reamer is being checked before it is driven home into the ilium.

the femur to slide down the ilium and to maintain a close approximation of femur to ilium. When the surgeon is satisfied with the gain in leg length, the patient is transported in his bed to the operating room. After anesthesia is induced, he is placed on the Hawley table. Only

a few moments' relaxation of the continuous traction existing in the bed is allowed during the interval before the fixed traction of the Hawley table is substituted. The amount of abduction of the legs is determined by the requirements of the individual case. Seldom more than fifteen degrees is desired. A slight modification of the Smith-



Fig. 4.—Hip of same patient as shown in Figs. 2 and 3, seven months after operation. The bony shelf is well-formed of massive supporting bone. The bone peg has held to maintain length during this bone formation. The position of the leg, in slight abduction with the gain in length obtained by the preliminary traction, has overcome more than one-half of the shortening existing in the leg before operation. The patient now walks without support of any kind, climbs stairs, and the leg is gaining in muscular and bony strength.

Petersen incision exposes the hip area. The iliopsoas muscle is retracted mesially, exposing the wing of the ilium and upper part of the neck of the femur. In the position obtained on the table, this is found well apposed to the ilium, leaving, however, sufficient space to freshen with a chisel the end of the neck or the partially destroyed head and surface of



Fig. 5.—A similar end-result in a girl fourteen years old. The bony shelf was added in this instance by some spicules of bone from the tibia. One can still see remnants of the outlined area in the ilium, from which the shelf flap was fashioned. Firm bony fusion followed after eleven months, with freedom of all accessory support and gain in leg volume and strength.

the ilium. The greater trochanter is then split vertically downward by a chisel, following the Wilson technic, pried outward without complete separation from the shaft of the bone. The surface of the ilium is

marked out with a chisel for a quadrilateral bone flap long and wide enough to turn down into the split trochanter. This flap takes much of the thickness of the ilium and in turning down is cracked across and hinged at its base. Its function is purely osteogenetic. If a hole clear through the ilium occurs, it need cause no worry. Some osteoperiosteal grafts, taken from the neighborhood, may be packed around this open bone, according to Key's method. A large reamer is then driven obliquely upward through the subtrochanteric portion of the femur into the adjacent ilium or upper acetabular area, as deeply as it may go without complete penetration into the pelvic cavity. The position of the reamer may be checked at this stage by roentgenograms. If a satisfactory angle and penetration are secured, a bone transplant is cut from the anterolateral surface of the tibia to fit the reamed-out channel and is driven home. No effort is made to round off the transplant, and any excess bone material from the tibia is packed in around the denuded area of the hip. The wound is closed and a double spica plaster of Paris dressing is applied, including the whole of the operated-upon leg and the opposite leg to the knee.

After twelve weeks, if the roentgenogram shows the position at the hip well maintained, the Steinmann pin may be withdrawn from the heel or femur, but the plaster of Paris encasement is left on until a total period of at least sixteen weeks has elapsed. The roentgenologic examination, after removal of the plaster, normally shows considerable new bone formation at or about the shelf, with the indriven bone transplant holding its fixed position. Within a few days, the patient is permitted to become ambulatory on crutches, wearing an elevated sole on the shoe of the normal foot to avoid weight-bearing on the still forming fusion until roentgenologic evidence is furnished of sufficient bone formation to withstand the pressure of body weight, partially taken up by a walking caliper. This interval may be two or more months, after which the raised sole may be removed from the well foot and a walking caliper applied to the operated-upon leg.

During this interval, knee joint motion is restored by exercise and physiotherapy applied when no weight is borne on the leg.

The patient finally begins to bear weight without crutch or splint support, using a minimal additional thickness of sole under the short leg to avoid pelvic tipping and spinal deviation. A rapid, safe functional use of the limb develops along with increased power and muscular volume. This ultimately leads to increase of bone strength in the operated-upon leg.

One of my patients is now performing active work as a farmer, one as a business secretary. They walk with some lameness which is painless, and are able to climb steps readily. This procedure is of value in giving a feeling of security to the patient, in reducing the pain and

distress of a sliding, painful hip, and in regaining some of the lost leg length. From an industrial standpoint, it also reduces the permanent, total disability.

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TREATMENT OF FRACTURE OF THE UPPER JAW

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LOUIS T. BYARS, M.D., ST. LOUIS, MO.

THE upper jaw, surgically considered, includes all of the bones of the face except the mandible and frontal. It forms the framework of the middle two-fourths of the face, gives support to the nose and anchorage to the upper teeth, and constitutes the roof of the mouth, the floor and walls of the nasal cavity and of the orbits, and entirely bounds the maxillary antrum. Here fracture lines disregard anatomic boundaries (Fig. 1).

In the oral portion, the bone is of considerable thickness, is densely cancellous, and is buttressed by the pterygoid process behind, the malar buttress laterally, and the base of the frontal processes in front. The upper part of the maxilla is made up largely of thin, dense plates, which, besides partitioning off the facial cavities, form a trestle that distributes the attachment under the whole of the anterior half of the brain case.

Fractures of the alveolar process of either jaw fit roughly into three classes: In one, a section of the outer or inner table is pushed buccally, labially, or lingually, and frequently carries teeth with it. In the second type, a mass of alveolar process, including the contained teeth, is torn loose from the body of the bone; and in the third type, the plane of fracture is more or less vertical and transverses both the alveolar process and the body of the bone. Alveolar fragments are not apt to become entirely detached, and the mucoperiosteum which carries a good blood supply is so closely adherent to the alveolar bone that the vitality of these fragments can usually be preserved. In some instances, an area of bone becomes shattered into rather small splinters, usually mixed with fragments of roots and even of the crowns, driven deeply into the bone. If in such a case the comminution is limited to the alveolar process, the immediate removal of all detached pieces will likely save a long period of suppuration. If the comminution extends deeply into the body, especially of the lower jaw, then it might be safer to wait until sufficient hard callus has been deposited to insure preservation of both contour and continuity.

In every type of block alveolar fracture, the fragments and still attached teeth should be replaced as accurately as possible and retained

either by dental ligatures or some more formal dental appliance. If it is thought that any teeth can be retained after the bone has united, the dentist should have the privilege of seeing them early.

The upward tilt of a stellate fracture of the palate usually requires only replacement by pressure made from within the nose.

In the upper maxilla, actual tearing apart of the fragments can occur from great violence, but more commonly it is fissured, comminuted, or impacted without complete rupture of the periosteum, more or less resembling the crushing-in of a portion of an eggshell. Breaks in the zygomatic processes have more the character of long bone fractures, including the possibility of displacement by muscle pull.

Fracture lines above the palate can go in any direction, but besides a possible vertical separation of the two halves of the maxilla, there

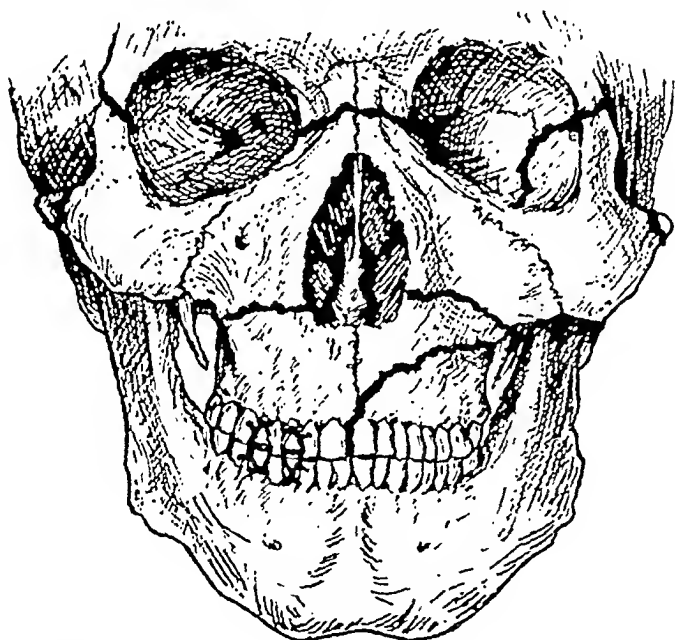


Fig. 1.—Fracture lines. An alveolar body fracture is shown running from between the central incisor teeth, disappearing around the antral wall on subject's left. The more distinct types of body fracture are:

1. Lower transverse—traversing the maxillary bone, through the antra and the nasal fossae, and the palate bone and the vomer. Posteriorly it likely traverses the sphenopalatine fossae and fractures either the palate bone or the pterygoid process of the sphenoid bone.

2. Upper transverse—traversing the right temporal fossa, through the orbit via the frontozygomatic, sphenozygomatic sutures, the inferior orbital fissure, the ethmoid, lacrimal, maxillary (frontal process), and nasal bones and vomer.

3. Zygomatic (malar) fracture—traverses the zygomaticomaxillary fissure, the inferior orbital fissure, the sphenozygomatic, the zygomatic frontal sutures with usually a comminuted fracture of the outer wall of the antrum. The zygomatic process of the temporal bone can be fractured anywhere, but the separation usually occurs at its junction with the temporal process of the zygomatic bone.

4. Push-back fracture, not here shown, is a backward shifting of some or all of the bone lying between the orbits, the zygomaticomaxillary sutures, including, possibly, the whole intraoral part of the maxillary bones. This of necessity includes a comminution of the laminae and processes lying deeper in the facial structure.

The above are meant rather to suggest the most likely course that the lines will take in any particular type of fracture, but types may merge or mix, and it is probable that these lines might vary in individual types.

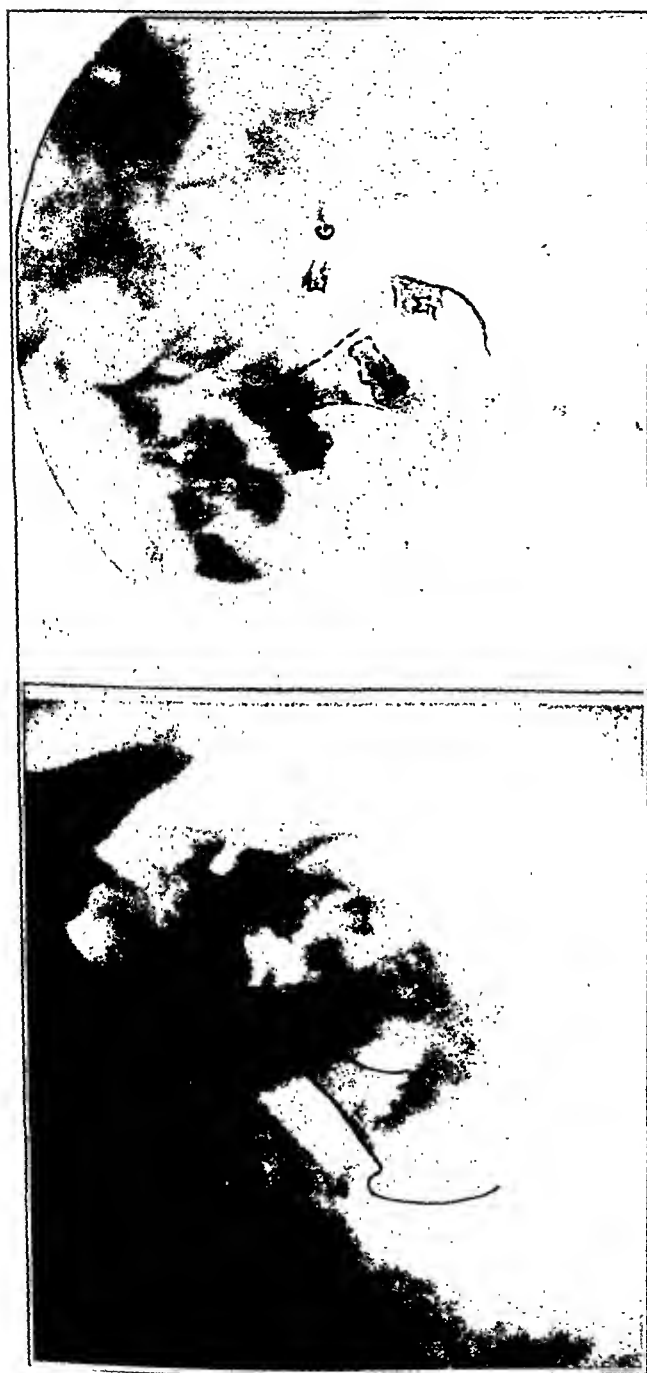
are four somewhat distinct types of body fracture. The first is along a transverse plane, partial or complete, through the antra and nasal cavity, maybe with incidental radiating fractures, but usually with little or no tearing of the oral mucosa. The whole intraoral mass, or a portion of it, may be quite movable, in which case it is treated as will be described for complete transverse fractures through the orbits. If there is any impaction, the displaced fragment should be freed before fixation is attempted.

Another plane of transverse fracture is through the orbits and nasal cavity. This, or the one just referred to, may be but a fissure in the bone with little tearing of the covering, to be detected only by elicit-



Fig. 2.—Upper transverse fracture. A. Shows the down-drop of the face when the patient entered hospital. B. Shows the face made shorter and apparently wider after the sagging maxillary mass had been brought to its proper position.

ing a slight movement while grasping the vertex firmly in one hand and dental arch with the thumb and fingers of the other; or the whole detached mass can sag down one-half inch or more, giving a characteristic elongation to the face (Fig. 2). This fracture may be complicated by extension into the brain case and tearing of the dura. There may be an injury to the sixth nerve, or the optic nerve may be crushed or divided. Blindness in one eye following this type of injury is much more frequent than might be supposed, but it so happens that we have never seen or heard of its bilateral occurrence. No matter how slight the mobility, the possibility of a fracture into the base should always be considered.



B.

A.

FIG. 3.—Muscle balance. A and B, Show the six-year-old mandible of a child who at three months lost both condyles as the result of fracture of the neck and hematogenous infection. If carefully examined, it will be seen that there has been little growth in length of the ramus proper, but that the coronoid processes (C) have elongated until the tips are in their proper relative positions. Also that there is a very appreciable interval between the ramus (M) and the articular eminence (E), and glenoid cavity (G). The child can move the jaw laterally, up and down, and with the anterior fibers of the temporal muscle, can bring it somewhat forward. It has, in fact, all the ordinary chewing motions without the great power of the normal jaw, and carries in it a natural position when awake, but if in sleep she turns on her back she will awaken because the jaw and tongue drop back and shut off respiration.

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appropriate upper and lower teeth or by a dental splint. There being no muscle pull to overcome, neither the wiring or the tooth anchorage need be as strong as in fracture of the body of the mandible. If there are no remaining teeth, the patient's dental plates can be made into a splint, as in treating an edentulous fracture of the lower jaw. Either plan will maintain the proper relation of the jaws to the face, even when the lower jaw is also badly fractured, this being dependent upon an acquired habitual tension balance of the muscles of mastication. (Fig. 3.)

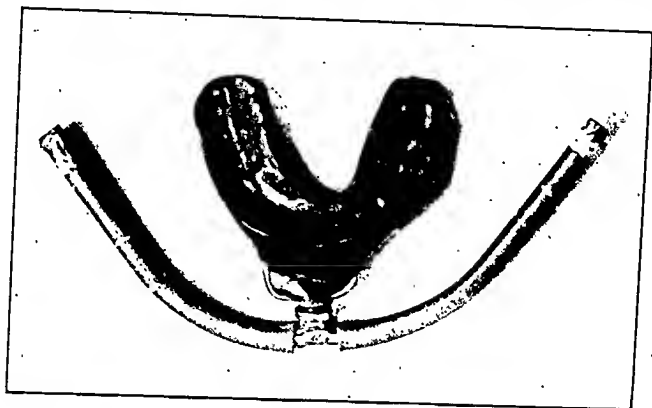
In most lower jaw fractures, the earlier the reduction and fixation, the better; this is true of gravity displacements of simple transverse fractures, but with extensive impactions of the upper loculate part, a week or ten days on the average had best elapse before disturbing the



Fig. 5.—Overcorrection of a sagging jaw after a lower transverse fracture. *A*, Shows the relation of the dental arches three months after injury, the result of continuing overlong a too energetic up-pull. The septum was bent, and the anterior nasal spine, the floor of the nose, and the base of the columella were also displaced upward, giving a "hooked" appearance to the nose. *B*, Shows relations restored which were made possible by the free use of a chisel. Teeth are held in place by an upper and lower wire ligated to the neck of each second bicuspid. Feeding in this case was through the space resulting from the loss of the left lower molars. It is rare that sufficient semisolid food cannot be taken through the mouth while the dental arches are fastened together, but in any event, it can be forced through a small catheter that rests in the upper esophagus and passes through the nose.

communion. One reason for recommending this interval is to give time for a possible spreading infection from quiescent foci to become evident, and to avoid the possibility or the imputation of having aggravated this complication. Further, this time might be profitably used to improve the general and local condition of the patient. This inhibition refers particularly to the forceful and difficult breaking up of impactions, hardly to the molding and replacing of already loose fragments.

For fractures in either plane with no displacement and little excursion, one might rest content with prohibiting all chewing for three weeks, being alert to a possible increase of the false movement. Where there has been a real separation, the basic principle of treatment is



A.



B.

Fig. 4.—Temporary elevation of the sagging jaw. A, Klingsley type of splint with lateral outriggers made for the case by Dr. J. A. Brown, of St. Louis. B, Shows the splint in position supporting the jaw by means of a slight, elastic, upward pull of a strip of rubber dam.

the same as for fractures through the substance of the lower jaw, namely, fixing the dental arches in occlusion either by wiring together

occlusion which could seriously compromise an otherwise good result (Fig. 5). For this reason the jaws should be fixed in occlusion within two or three weeks after injury.

Another fracture displacement of this region is of the zygoma or malar bone, and this is almost always impacted. One common displacement is inward and backward; another is slightly downward, and outward and backward, which latter displacement may interfere with the forward movement of the coronoid process of the mandible, thus limiting mouth opening (Fig. 6). In either instance, the continuity of the lower, or lower and outer orbital borders, and of the floor of the orbit is more or less disturbed. One of the most commonly slighted complications of this fracture is a downward or backward displacement of the globe, because it is so easily overlooked in the earlier period (Fig. 7).

The classic way of freeing malar impaction is by leverage or traction from without. Gillies has proposed a very practical plan of exerting powerful leverage by inserting a long steel elevator through a small incision above and behind the ear at the temporal ridge. The instrument passes under the temporal fascia until it enters the anterior part of the zygomatic fossa where it is in an advantageous position to manipulate the body and the temporal process of the zygoma. This approach has the advantage of being quite simple to execute. Through a larger incision we have used this approach to chisel an old malunion and to insert an ivory pillow-block under the end of a mesially displaced zygoma. Because of the considerable number of late cases that we have seen in which malar fracture was followed by a permanent slump or retraction of the globe, we have been rather routinely following a different plan. Observation of a considerable number of penetrating wounds of the antrum with all ordinary types of war missiles, in various stages after injury, seemed to make the attempt justifiable. Usually under a general anesthetic, the mucosa is incised, and a chisel is driven into the antrum above the first molar or premolar teeth, the chisel frequently entering the fracture line. Good leverage for freeing the impaction of a mass displacement of the malar bone can be had by inserting a heavy curved nethral sound within the antrum. This combined with digital manipulation from without usually gives satisfactory control. If there is much comminution, especially of the orbital floor, the anterior wall of the antrum is pried outward sufficiently to admit the examining finger, which assists in the molding after the major impaction has been completely freed. Perfect restoration of contour may be very difficult, or impossible, mostly on account of a slight but persistent flattening of the zygomatic prominence. More perfect correction might in some cases be obtained by using both the intramaxillary and the temporal approach. Through

Usually the orbital contents need no local attention in the upper transverse fracture. An incidental downward displacement of the eyeballs should in uncomplicated cases be automatically corrected by the raising of the maxillary mass. Unless symptoms dictate otherwise, antral drainage is omitted in lower transverse fractures, but patulence of the nasal passages must be assured. Fractures in either the upper or the lower plane may cause obstruction to nasal breathing simply from mucous swelling, if not from bony displacement, and this swelling might also extend to the mouth and pharynx, so that immediate fixation of the jaws in occlusion could seriously embarrass respiration.



Fig. 6.—Open fracture. *A*, Shows natural healing of a wound with outward and downward displacement of the zygomatic bone. *B*, Shows the result of loosening the displaced bone and fastening it in a fair position where it was held by one removable, very fine silver wire loop and numerous fine sutures of triple A white silk, the silk sutures were placed mostly through periosteum or adherent scar. A partial repair of the soft tissues was then made, and some pieces of cartilage were implanted. Later the final soft tissue adjustment of the lids will be completed.



Fig. 7.—Displacement of the globe. *A*, Shows a residual flattening of the malar eminence and the downward and backward displacement of the eye in a patient with whom the preservation of life and not the position of the bones was the all-absorbing consideration for many weeks after injury. *B*, Shows the improvement which resulted from rearrangement of the soft tissues and implantation of cartilage and small amount of a plastic filler.

Gravity displacement in the predental-fixation interim can be most simply and very effectively controlled by the use of a Kingsley splint reversed, held up by a slightly elastic pull or some other similarly acting appliance (Fig. 4). This splint was formerly regarded as a proper permanent fixation for these sagging fractures, but if there is comminution at the line of fracture, the upward pull can easily become over-, or inaccurately, correct, thus causing a discrepancy in

the latter, the chisel might be judiciously used. The contour of the cheek bone can be estimated with fair accuracy by standing behind and above the patient, with the ball of one index finger on each malar eminence and sighting down the midline of the face, checking the forward position of the dorsal surface of the fingernails on either side, using the line of the brows as a guide. Some allowance may have to be made for swelling on the injured side. The examining finger can ordinarily invaginate the lower lid and feel the lower orbital border and one centimeter of the floor. When this part of the zygomatic bone has been pushed downward, the finger can feel still further in. Carefully palpating under the upper border of both orbits,

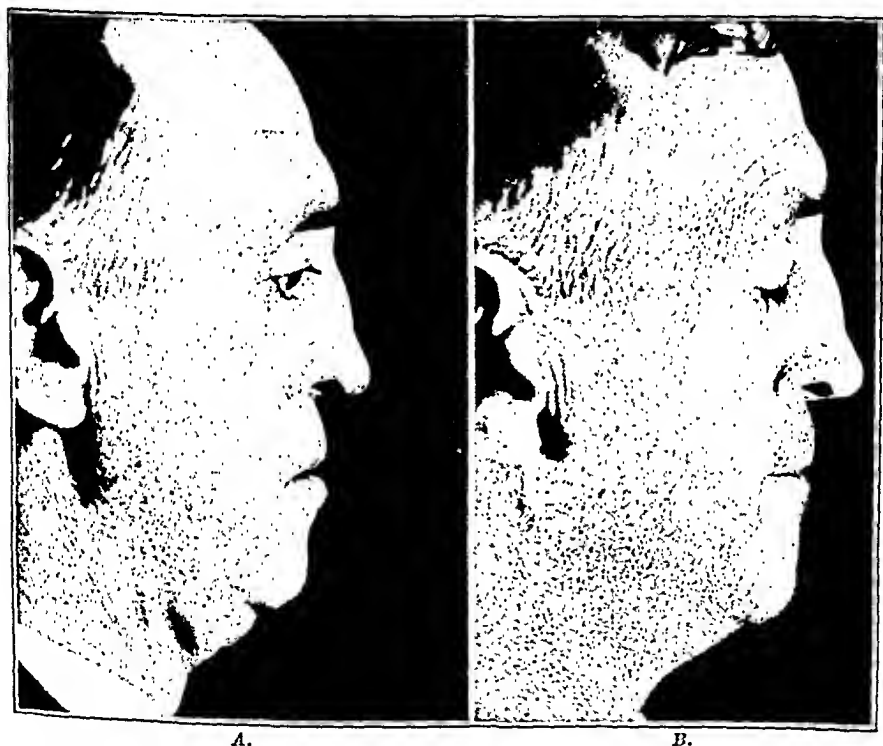
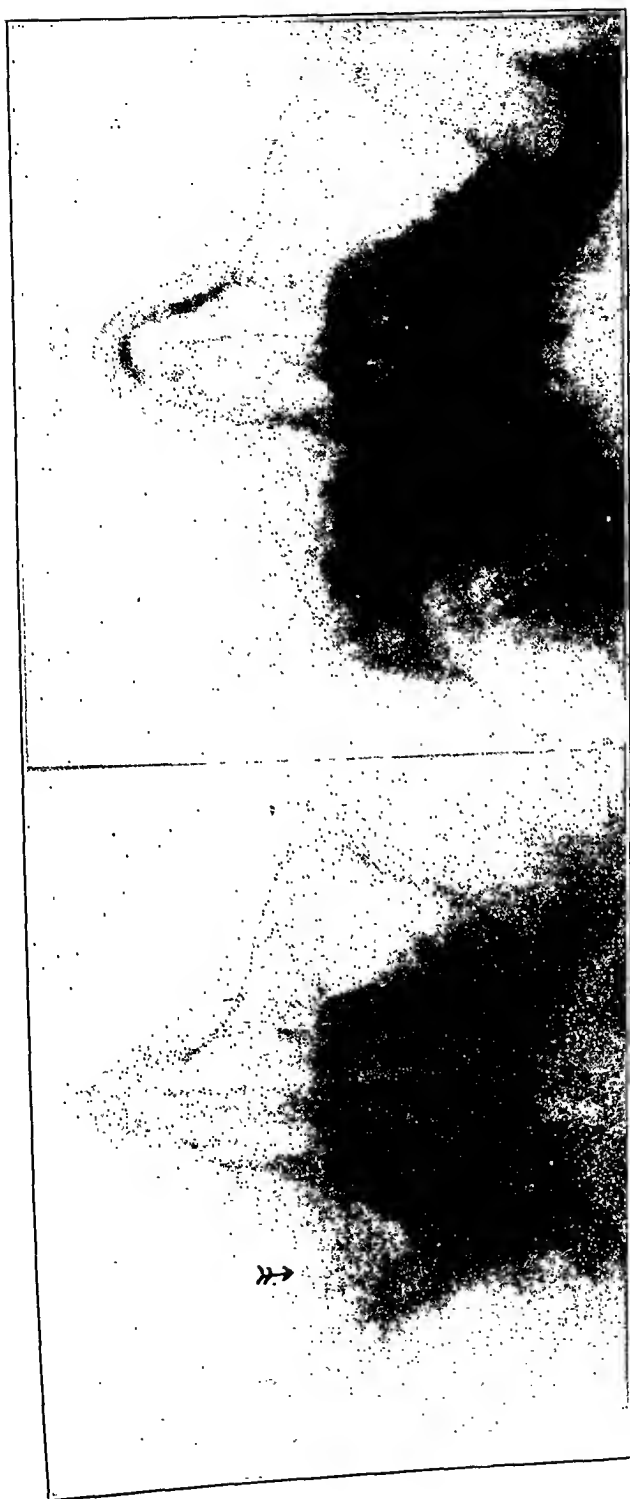


Fig. 2.—Massive push-back fracture. A, Shows the receding of the middle part of the front of the face. This would appear even more pronounced were it not for a fracture loss in the right side of the mandible which caused an incidental retraction of the chin. B, Shows the improvement in appearance brought about by (1) expanding the lower jaw and bridging the gap with a bone graft from a rib, and (2) advancing the cheeks, upper lip, the ala, tip of the nose and the columella on the maxilla and nasal septum. It is likely that the still remaining infraorbital depressions will be eliminated by the use of cartilage implants. So much for appearance. The backward position of the lower part of the maxilla has crowded the nasal pharynx with a resulting embarrassment to the eustachian tubes and impairment of hearing. The latter is improving under the care of an otologist, but the threat of deafness has not been entirely removed. The writers do not believe it would be good surgery to attempt to bring this jaw forward at this late time. In another such case in which, in spite of the best of otologic care, the hearing could not be restored, the bone of the palate process, the septal part of the vomer, and the posterior part of the inferior turbinate bones were removed, and the soft tissues of the palate sutured. This resulted in a practical restoration of the hearing in one case.



B.

A.

FIG. 8.—The antral approach and pack. A, Shows the depressed infraorbital border incidental to a zygomatic fracture. The arrow indicates the displaced fragment, beneath which can be seen the contracted antral cavity. B, Shows this border brought up to symmetry with the fellow, and the antrum now expanded to its natural size and filled with the gauze pack impregnated with balsam of Peru and iodoform. The ordinary radiogram of an upper jaw fracture is all but useless. The definition of the antra and the infraorbital borders was obtained by projecting these structures upward against the rather patternless vault of the skull.

Enough of the pack is allowed to protrude into the buccal fornix to maintain some elevation of the outer wall of the antrum (Fig. 8). The cavity can be irrigated daily through the tube, and the gauze is removed two or three weeks later. The thumb pressure on the cheek partially replaces the everted antral wall, and the irrigation is continued for some days or longer. The final replacement of the raised part of the antral wall seems to come from muscle pressure. Where there is no tendency for bony displacement to recur, the packing may be omitted, but the drainage and irrigation should be continued for a few days.

In the past eighteen years, we have so treated quite a number of antral fractures and have had no real complications, with the exception of two that we can recall. In one, the bone was released and replaced and the antrum packed a day or so after injury. There resulted an acute reaction followed by some necrosis of the antral wall, but the symptoms cleared up, and the fistula closed after removal of a piece of exfoliated bone. This may have resulted from too early interference. The other case so treated ten days after a widespread injury suffered recurrent attacks of swelling, fever, and pain at intervals over a long period of time. These attacks ceased after the antrum was opened and a mass of sear, probably including some sequestered particles of bone, was removed.

A fourth rather distinct type of maxillary fracture is a bashing-in of the central part of the face, usually involving the nasal bones, frontal process, inner part of the intraorbital border, and perhaps a varying amount of the lateral borders of the nasal fossa, or maybe the whole lower part of the bone. This may be on one side or bilateral.

When seen before malunion occurs, more or less satisfactory reposition of the displaced bone can be accomplished with a chisel, and leverage applied from within the nose and through the anterior wall of the antrum. The released mass might have to be held forward by a wire armature, which, pushing from within the nose, gets its footing from a dental splint, a plaster head-cap, or a fracture helmet. The dental splint type is usually the most satisfactory. If the backward force was applied to the lower part of the bone, the dental arch, hard palate, and pterygoid processes may all be pushed back until they crowd the nasopharynx. If this is not corrected, the persisting lack of occlusion and evident facial deformity may be of minor importance compared with the permanent impairment of hearing that can result from crowding of the eustachian cushions and orifices. (Fig. 9.) If the force is applied high up on the nasal bridge, the nasal bones can be pushed backward between the frontal processes, or the bony arch might flatten out, pushing the inner orbital border outward, so as to impinge on the orbital cavity (Fig. 10). To correct either of these two deformities when seen early, one might find it convenient to work

one can make a fairly accurate estimate of any downward or backward dislocation of the globe. The outer and lower borders, the temporal process, and the intraoral surface can all be palpated. In this way a much more accurate diagnosis can be made of a changing position of contour of the zygoma and its processes than can be obtained from the examination of the average x-ray film.

After the body and orbital floor and borders have been replaced, a Dakin tube (maybe two) is wired to a tooth and led up into the upper part of the antrum with all the perforations within the cavity. The cavity is then gently, but with some firmness, methodically packed



Fig. 10.—High push-back fracture. *A*, Shows a case where the median orbital borders have been pushed outward, displacing the inner canthus and shortening the palpebral fissure. There is a corresponding flattening of the nasal bridge. *B*, Through vertical, semilunar incisions, the soft tissues were pushed outward, including the lacrymal sacs, which were dislodged from their proper fossae in the lacrymal bone. This necessitated division of the internal palpebral ligaments. The displaced bone was chiseled away, opening into the nose. The internal palpebral ligaments were temporarily replaced by a forty-day fine catgut loop which engaged each inner canthus and passed directly through the nasal cavities from one side to the other. One should attempt to get this stitch far back where it belongs. Later in all these cases, scar has proved a satisfactory substitute for the ligament.

Fig. 11.—Prosthetic restoration. *A*, Shows loss of anterior half of alveolar process and hard palate and part of upper lip from a bullet wound. *B*, Shows restoration by (1) releasing lips and cheeks from remaining bone and preserving this newly-made sulcus by lining it with a split skin graft put in on a wax form; (2) piecing out the lost part of the lip by switching a flap from the lower lip; (3) the use of a dental prosthesis which carries the needed teeth and fills out the contour.

with a one inch or wider folded strip of iodoform gauze, lightly impregnated with balsam of Peru, so placed as to maintain the bones in position and also placed so that it may be withdrawn without snarling

CHRONIC SUBDURAL HEMATOMA: A CONDITION THAT FOLLOWS EVERYDAY ACCIDENTS

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A GREAT deal of attention has been directed toward the diagnosis and treatment of acute injuries of the head; in the treatment of such injuries, emphasis has been placed on immediate hospitalization, rest in bed, observation, and treatment of complications as they arise. However, insufficient attention has been directed toward the possible sequelae of mild injuries of the head that are accompanied by slight or no surface trauma, no evidence of fracture, and so little discomfort or disability at the time of the accident that the activities of the patient are not curtailed. Among the latent developments in these cases are the so-called posttraumatic syndrome which consists of headaches, generalized weakness, unstable emotions, and subdural hematoma. The treatment of the posttraumatic syndrome consists of rest in bed, administration of sedatives, and encephalography in selected cases. Subdural hematoma requires operative removal.

Chronic subdural hematoma has been confused with pachymeningitis hemorrhagica; in the minds of some surgeons and pathologists there is a question as to whether the pachymeningitis hemorrhagica is the result of infection and causes the accident or whether the chronic subdural hematoma develops after the accident, from a tear in the small veins associated with the longitudinal sinus or from a tear in the sinus itself. Putnam and Cushing expressed the opinion that there were two types of hemorrhagic subdural hematoma, (1) the vascular type which is seen frequently at necropsy on patients who have died of chronic alcoholism and chronic wasting diseases, and (2) the reactive or traumatic type. The recent literature on the subject proves that chronic subdural hematoma is a much more common condition than has heretofore been suspected. When the condition is diagnosed early and treated surgically, restoration of the patient to normal and the relief of severe symptoms in the postoperative period are dramatic. Subdural hematoma may occur at any age and may affect either sex, but it seems to be more frequent among men because of their greater exposure to injury. Subdural hematoma should be suspected in any case in which symptoms of increased intracranial pressure or intracranial difficulties develop from a few days to months after an injury to the head. The usual points in the history are headache, vomiting, gradual diminution in

directly through one or more local skin incisions. If seen after bony consolidation has occurred, regardless of the type of fracture or displacement, it is not often that anything much can be gained by attempted late bone adjustments. Displaced bony masses, such as impinging orbital borders or protruding corners, might have to be removed, but beyond this building-up the depressed or lacking areas with cartilage or some soft tissue transplant other than free fat will give the best corrective results.

Open and gunshot fractures of almost any kind can occur with or without an actual loss of bone or maybe its covering. The ordinary indications for their treatment are: (1) to care for the general condition of the patient, (2) to remove no attached fragment of bone, (3) to fix displaced fragments in proper position, and (4) to not compromise the result by any strained attempt to immediately close soft tissue rents.

Intraoral losses of maxillary bone are best compensated for by a dental prosthesis. To make this feasible may require the release of abnormal tissue adhesions, implantation of skin grafts, or the switching of mucous or skin flaps, but if all or a greater part of the intraoral mass has been lost, the prosthetic dentist should have access to the care before the soft tissues have become contracted by scar. (Fig. 11.)

which had been followed by a severe headache which had lasted all day. On the following morning she had had three convulsions. A large dose of sedatives had been administered, and she had been sent to the clinic in an ambulance.

When she was admitted to the hospital, she complained of headache and was emotionally upset. Examination revealed nystagmus and ataxia. The temperature was 102° F., and the blood pressure was within normal limits. We were inclined to suspect a chronic subdural hematoma or delayed hemorrhage following the cranial injury. The day after her admission to the hospital the temperature was normal; there was slight ataxia, but the nystagmus had disappeared, and the child was clear mentally and stable emotionally. Ophthalmoscopic examination did not reveal choked disks, but there was a small retinal hemorrhage on the nasal border of the left optic disk. A preliminary diagnosis of chronic subdural hematoma was made and operation was considered, but because of the absence of papilledema and because of marked improvement in the condition of the patient, operation was postponed. Spinal puncture revealed yellow cerebrospinal fluid which was under increased pressure. The condition of the patient was much improved after the first spinal puncture, and daily punctures were done for five days. The symptoms all disappeared, and when the patient was dismissed, she was completely relieved. Her condition was not the result of chronic subdural hematoma, but was caused by a subarachnoid collection of sanguineous fluid.

The relief which followed lumbar puncture brings up the question of the use of this procedure in cases of injury to the head. There is some controversy over its place in the diagnosis and treatment of acute conditions, but in the chronic or delayed conditions, its safety is almost assured. The foregoing case is proof of its therapeutic value. In the presence of papilledema or choked disks, however, spinal puncture is contraindicated.

Chronic subdural hematoma may occur at any age, and if it affects infants, the damage to the brain is sometimes extensive and permanent. The following case illustrates what may happen when a child falls out of its crib.

CASE 2.—A boy, ten months of age, was brought to the clinic by his parents because of generalized convulsions, which involved the left arm and leg, and because of weakness in the left arm and leg. The history was of interest, because the child had been delivered through a cesarean section after the mother had been in labor for approximately four hours. At the age of six months, the baby had fallen out of his crib and had been found with the back of his neck against the wooden bar of the bassinet, close to the floor. The child had not cried and external evidence of injury had not been present. At the age of nine months, the child again had fallen out of his crib, and at this time a bruise had been noted on the right forehead. Three hours after the accident, there had been a generalized convulsion which had lasted from twenty to thirty minutes, and after an interval of two days another generalized convulsion had occurred. Shortly after this, generalized convulsions had been preceded by a jerking of the left arm and leg, and following the convulsion there had been a definite weakness of the entire left side.

Examination at the clinic revealed that the child was well nourished but inattentive and slow in response. The head was larger than normal and a cracked-pot sound and a bruit were present over the occipital region. There was a definite weakness of the left arm and leg, which was more characteristic of a hemiparesis than a paralysis. The roentgenologic examination of the head revealed dilatation and

visual acuity, diplopia, convulsions, and mental disturbances. No one factor is common to all cases, and in spite of the fact that localization of the hematoma is fairly constant over the convex portion of the cerebral hemisphere, the findings on neurologic examination are extremely variable and frequently so confusing that in order to make the diagnosis, it is necessary to resort to ventriculography.

The fact that subdural hematoma occurs after trivial injuries to the head brings up the question of the mechanism of the development of the blood clot. Most of the investigators have concluded that the source of hemorrhage almost always is one of the branching veins running from the cerebral cortex across the subdural space into the superior longitudinal sinus. Once the clot has formed, the latent period is rather difficult to explain. Zollinger and Gross explained that liquefaction probably takes place within the clot, and that the wall of the sac acts as a semipermeable membrane. They further stated that the fluid contents of the sac, which have a higher osmotic pressure than does cerebrospinal fluid, increase in volume as a result of osmosis, thus gradually distending the sac. This explanation has been questioned, but up to the present time it seems to be the most satisfactory solution of the problem.

The treatment of the condition is entirely surgical, and osteoplastic flaps formerly were reflected in all cases. Later, Fleming and Jones suggested two trephine openings, one placed posteriorly and one, anteriorly, for the purpose of aspirating and washing out the contents of the sac. McKenzie has recommended the removal of the contents of the sac by suction through a small opening in the bone and subsequent drainage of the subdural space for forty-eight hours. Just as is the case in so many surgical conditions, no single procedure is applicable in all cases, and while the aspiration of the contents may be tried through one or two openings, an osteoplastic flap should be reflected in those cases in which the clot is still partly solidified and extends beneath the temporal lobe. On one or two occasions, subdural hematomas which apparently had been removed through one or two trephine openings have been exposed through an osteoplastic flap, and the residue of the clot was found to be causing a residual of symptoms. After the entire clot had been removed an uneventful convalescence followed. It is true that some trivial injuries to the head are followed by symptoms which simulate those of chronic subdural hematoma but which respond to more conservative treatment. In order to emphasize this point, the following case is reported.

CASE 1.—A little girl who was sent to the clinic had fallen from a tree and injured her head, three weeks previously. The accident had not been considered serious, and the child had been allowed to be up and about, and she had attended school. The day before she was brought to the clinic, while she had been in school, she had had a generalized convulsion which had lasted about thirty minutes and

tionable localization, it was decided to make a ventriculogram. Trephine openings which were made over the posterior horns, disclosed that the dura was discolored on both sides. When the dura was incised, dark blood escaped. Trephine openings were then made anteriorly, and 250 c.c. of a liquefied blood clot was removed by means of suction (Fig. 1). Immediate relief of headaches and vomiting followed the operation, and the choked disks began to subside. The patient was allowed to return to his home on the tenth day after operation and has been perfectly well since that time.

This boy had choked disks, severe headaches, and vomiting; and he was becoming dehydrated. His symptoms had appeared six weeks after a minor injury to the head. The hematoma was bilateral and had become completely liquefied, which allowed removal through multiple trephine openings. Bilateral hematomas are common and should be suspected in all cases in which removal of a hematoma on one side is not followed by relief.

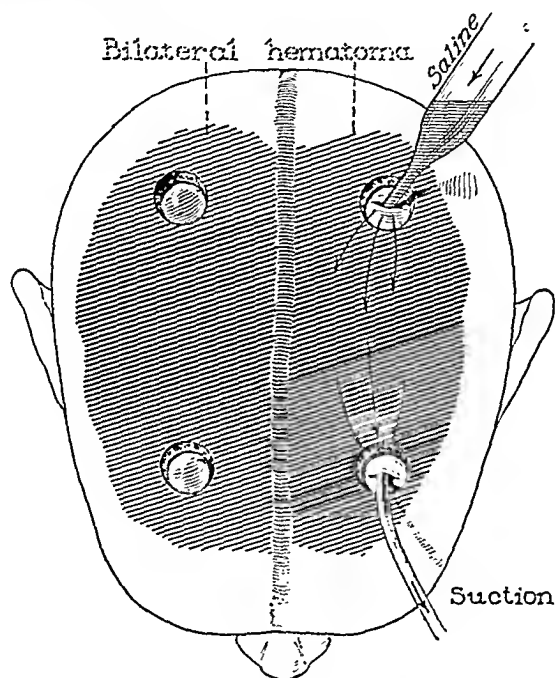


Fig. 1.—Bilateral hematomas removed by dual openings, suction, and irrigation.

Sometimes the injury to the head is severe enough to cause unconsciousness but little else.

CASE 4.—A farmer, aged sixty-five years, had been working in a barn, and a horse had fallen on him. When found, he had been unconscious for six or seven hours; he had been removed to his home. After he had recovered consciousness, he had complained of soreness in the neck, which had lasted for a few days, but he had been able to return to work. Six weeks later he had complained of occipital headache, nausea, vomiting, and general weakness. These symptoms gradually had increased in severity, and both lower extremities had become weak, which had necessitated his confinement to bed. He was brought to the clinic in an ambulance.

Examination revealed a choked disk of three diopters, which indicated an increase in intracranial pressure. There was definite weakness on the right side of his

separation of the sutures. The anterior fontanel was still open. There was no papilledema, and the entire examination of the eyes did not reveal any abnormality. Lumbar puncture was performed, and on examination the spinal fluid was found to be normal. Because of weakness on the left side and because of the jacksonian-like convulsions, it was suspected that a lesion involved the right motor cortex, but because of the enlarged head an internal hydrocephalus also was suspected.

Under local anesthesia, a lumbar puncture needle was inserted through the outer margin of the open anterior fontanel on the right side. The needle was inserted to a depth of 4 cm. but no fluid could be obtained. The needle was gently withdrawn, and when it was just inside the dura, a large amount of sanguineous fluid was aspirated. This indicated an external hydrocephalus rather than an internal hydrocephalus. After 30 c.c. of fluid had been removed and the same amount of air had been injected, roentgenograms revealed that the collection of fluid extended over both cerebral hemispheres and that the condition was a true external hydrocephalus. Following the aspiration, the condition of the patient improved, and for that reason a larger amount of fluid was withdrawn two days later. The improvement was only temporary, however, and after three aspirations it was decided to reflect a small osteoplastic flap in order to determine the true nature of the underlying condition and to attempt to relieve the condition.

Under local anesthesia a right craniotomy was done, and the very thin bone was reflected. The dura was bluish and appeared similar to the dura over a chronic subdural hematoma. When the dura was incised and reflected, a hemorrhagic membrane was encountered, which identified the lesion as a true chronic subdural hematoma or pachymeningitis hemorrhagica and indicated that the condition was probably the result of trauma to the head. The sanguineous fluid was aspirated and the right cerebral hemisphere was found to have shrunk; the convolutions were atrophied and covered with engorged vessels. A Penrose drain was inserted for permanent drainage. For a few days after operation, the patient improved definitely, but this was only temporary and the child died on the ninth postoperative day. Necropsy revealed a pachymeningitis hemorrhagica which extended over both hemispheres. It also disclosed thrombosis of dural lateral sinuses and marked dilatation of the longitudinal sinus, especially over the occipital region. The torcular Herophili was about three times its normal size. This probably accounted for the bruit which could be heard when the ear was applied to the occipital region. There was a large distended vein which extended into the medulla and cervical segment of the spinal cord. At first this distended vein appeared like syringomyelia. There was also a thrombosis of the right Rolandic vein.

The presence of bilateral lesions should be suspected in all cases of chronic subdural hematoma. The following case illustrates a satisfactory method of treatment through multiple trephine openings.

CASE 3.—A boy, aged fifteen years, had been kicked by a horse two months before he was registered at the clinic. He had been knocked forward on his face and head as a result, but he had been able to return to his farm work immediately. He had been in excellent health for the following six weeks and had not had any residual symptoms. He had then begun to have sharp headaches, which had come on especially when he blew a musical horn. Four days after the onset of these headaches, he had begun to vomit and had vomited every day for a week. The vomiting had been definitely projectile. He had not had any convulsions.

Roentgenologic examination of the head did not demonstrate the presence of a fracture. Examination of the eyes revealed choked disks of three diopters. A diagnosis of indeterminate intracranial lesion, probably subdural hematoma, was made. Because the symptoms were those of increased intracranial pressure, with ques-

was somewhat ataxic, which was suggestive of a cerebellar lesion. A ventriculogram revealed that the entire brain was displaced to the left, which indicated a lesion in the right frontal region. An osteoplastic flap was reflected, and the dura was found to be blue. When it was opened, there was a gush of sanguineous fluid within an organized chronic subdural hematoma. The blood clot, together with its capsule, was removed, and the wound was closed. The patient recovered completely and was dismissed from the hospital on the fourteenth day after the operation.

In this case, the entire hematoma could not have been removed through multiple trephine openings because of its extent and consistency.

Automobile accidents, however trivial, may be followed by latent symptoms of intracranial bleeding. The following case is more or less typical of the progress in such a case.

CASE 6.—A bank president, aged sixty-eight years, was brought to the clinic in a stuporous condition. Seven weeks previously, while he had been riding with his daughter in an automobile, the car had overturned, and he had sustained an injury to the head which had dazed him for a few moments. He had been perfectly well for five weeks following the accident, when he had noticed that his right leg dragged. He had joked about this to his family and to his colleagues, and no significance had been attached to it. While he previously had been well known for his accuracy, his colleagues at the bank had found that he was beginning to make mistakes. Soon his family had noticed that he was doing and saying things that he had not done or said before. He had been advised to take a vacation. At that time he had been mentally confused, and there had been definite weakness of the right leg. When he arrived at the clinic, he was practically comatose.

Examination revealed definite weakness on the right side of the body, including the right arm and right leg. The patient could be aroused only with difficulty. He had a choked disk of three diopters. A diagnosis of chronic subdural hematoma of the left cerebral hemisphere was made because of the change in personality and weakness of the right side. Operation revealed discoloration of the dura over the left frontomotor region, and an organized blood clot was removed through an osteoplastic flap, which was necessary, as the clot could not be removed through trephine openings (Fig. 3). The entire brain had been displaced to the right side. The cavity on the left side was filled with physiologic saline solution, and the wound was closed. The morning after the operation, the patient was sitting up and joked about his illness. He had complete control of all his mental faculties. His family said that he was more like himself than he had been for weeks. He has completely recovered and is working every day.

Slight injuries to the head which are almost too trivial to be mentioned may be the cause of hematomas. Frequently, when no mention of an injury to the head has been made in the preoperative history, the patient can recall such accidents only with difficulty.

CASE 7.—A patient who had been in coma for five days was brought to the hospital on a stretcher. His sister-in-law accompanied him to the clinic, but as she lived in a distant city and had not seen her brother-in-law for two years, she was unable to give a clear history. Because of the coma and a choked disk of four diopters, a tentative diagnosis was made of a deep-seated tumor of the brain, probably spongioblastoma multiforme or malignant glioma. Because the spasticity was

body, and all the symptoms were those of a tumor of the brain. At operation a large chronic subdural hematoma was found compressing the left cerebrum; an enlarged trephine opening was all that was necessary for the removal of the partly liquefied hematoma (Fig. 2). The postoperative course was uneventful. When the patient was dismissed from the hospital, the wound was healed; there was choking of the disk of less than one diopter; and the headaches and vomiting had been relieved.

The clinical picture may be confusing, as it was in the following case in which the presence of ataxia made localization of the lesion difficult.

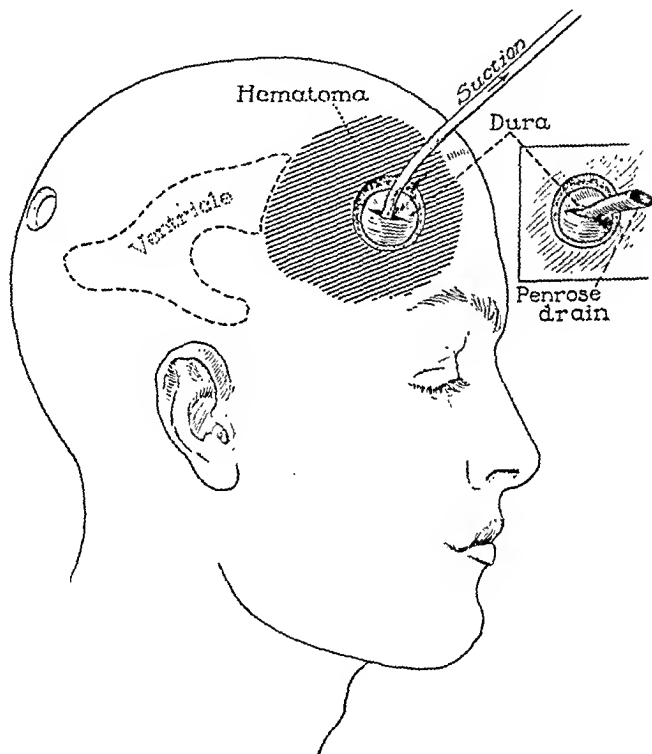


Fig. 2.—Hematoma localized by ventriculogram; removal of hematoma by suction and drainage.

CASE 5.—A man, aged forty-seven years, had been perfectly well until he had sustained a slight cranial injury when his horses had run away while he had been plowing. He had been thrown from the plow to the ground. He thought his head had struck a stone. He had been momentarily dazed and then had returned to his plowing. He had been perfectly well for seven weeks, when chronic headache had developed; this had occurred daily, at about 10 A.M., and gradually had increased in severity. A week after these headaches had begun, he had become nauseated and generalized weakness had developed. He had been more comfortable lying down, and he had refused to get up. Examination by the family physician had disclosed choked disks, and the patient had been brought to the clinic.

Examination disclosed bilateral choked disks of three diopters. Roentgenologic examination of the head for fracture gave negative results. The patient's gait

a definite capsule. The clot is incased in a capsule of fibroblastic tissue and feels like a rubber sac. The contents of the sac consist of fluid which has the color and consistency of bile. Another interesting thing is that when the clot is solid, it is laminated, as if small hemorrhages had occurred at intervals. The supposition is that the hemorrhage is of venous origin; that a small vessel in the longitudinal sinus is torn; and that the bleeding is encouraged every time the intracranial pressure is changed, as it was in the case in which the man blew the horn after he had sustained a cranial injury. It is common knowledge that during a craniotomy, bulging of the brain can be seen if the patient grunts or coughs while he is anesthetized, and any strain increases the intracranial pressure. After an injury to the head, a small hemorrhage probably occurs which increases with changes in intracranial pressure until it has become fairly large. The clot becomes organized; endothelial cells form a capsule around this clot; and liquefaction then takes place. This sac of fluid lies in the subarachnoid space and is in contact with the cerebrospinal fluid. It is believed that osmotic pressure causes absorption of the fluid, with the result that the sac enlarges. This explains the latent period and explains why the symptoms of chronic subdural hematoma simulate those of tumor of the brain. Intracranial pressure is increased, as is evidenced by headaches, vomiting, choked disks, and localizing signs, such as weakness of one or more extremities, nystagmus, and ataxia. If operation is performed early, it usually is followed by immediate relief of symptoms.

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greater on the left than on the right side, a large osteoplastic flap was reflected. This revealed a chronic subdural hematoma instead of a tumor of the brain. Because of the coma, the operation was performed with the patient under local anesthesia. During removal of the hematoma, he regained consciousness. He was asked if he remembered having bumped his head within the last six or eight weeks, and it was with difficulty that he remembered injuring his head while playing a cornet in a band two months previously. The man who had sat next to him played the bass horn; a few members of the band had been called up to the front, and as they had moved, the patient had struck his head against the bass horn. He had been dazed for a few moments, but had walked to the front of the room, had been able to play, and had not noted any discomfort.

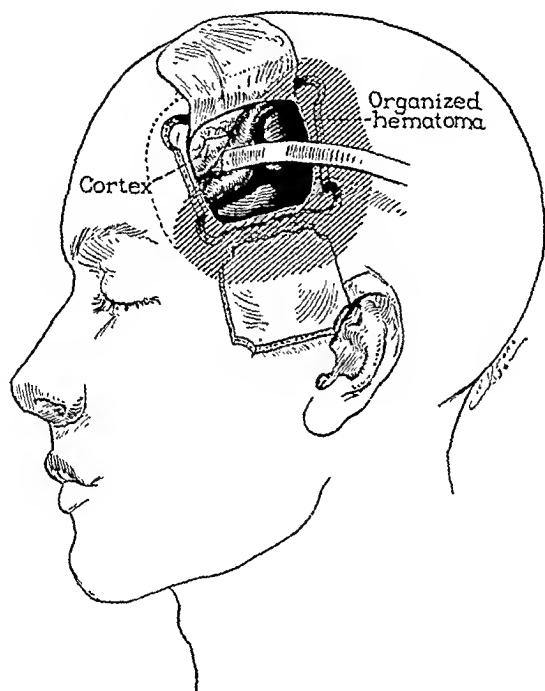


Fig. 3.—Osteoplastic flap necessitated by solid and semisolid hematoma.

COMMENT

A few years ago all the cases of chronic subdural hematoma observed at the clinic were reviewed, and it was surprising to find in how many of them it was impossible to obtain a history of cranial injury. Chronic subdural hematoma usually follows a slight injury.

In considering the pathologic changes, the question of chronic subdural hematoma being an ordinary blood clot is often raised. It is difficult to explain how a man may sustain a blow on the head and be perfectly well for six, eight, or ten weeks thereafter, before symptoms of intracranial injury appear. At operation, an organized, liquefying blood clot is found beneath the dura, and the dura can be stripped off



Fig. 1.—Sterile Petri dish of blood agar exposed to the air of the operating room during occupancy for one hour during the winter and incubated for forty-eight hours. The organisms are predominantly staphylococci, the albus predominating, while the aureus, hemolytic, and nonhemolytic varied with the number of carriers at the particular time that the cultures were taken. Where the incoming air is not washed and filtered, there may be many molds and spore-forming organisms, and the total count will be much greater. For a comparable culture made during the summer, see Fig. 2.

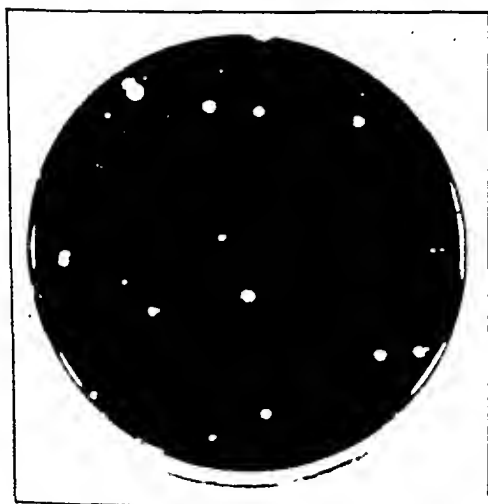


Fig. 2.—Culture similar to Fig. 1 made during the summer when the air contamination in the operating room is lower than during the winter. Here also the large number of molds and spore-forming organisms present in the outside air have been removed by washing and filtering the air, so that the culture plate shows predominantly staphylococci. Most of these probably entered the air from the occupants of the operating room.

STERILIZATION OF THE AIR IN THE OPERATING ROOM BY BACTERICIDAL RADIANT ENERGY

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(From the Department of Surgery, Duke University School of Medicine)

INFECTED wounds, usually mild but occasionally severe, are all too common in every surgical clinic. The percentage of infections is usually underestimated unless each infection is conscientiously recorded and the results tabulated. The most common etiologic agent is one of the staphylococci. The *Staphylococcus albus* infection is usually mild, while the *Staphylococcus aureus* infection may be mild or severe depending on the virulence of the particular organism, the resistance of the host, the suitability of the wound for bacterial growth (blood supply, traumatized tissue, hematoma, fat, foreign material as drains or ligatures, etc.), and the degree of inoculation.

While the occasional infection caused by other organisms such as the streptococcus or colon bacillus is likely to cause an investigation of the operating room technique, the staphylococcal infections are usually ascribed to imperfect skin sterilization (hands of the patient or of the operating room personnel). The streptococcal infections, on the other hand, have at times been traced to carriers in the operating room personnel who had the organisms in their noses and throats. The carriers of these organisms were so numerous during the influenza epidemic of 1918 that many operating rooms were closed except for emergency operations. At this time, however, I do not believe that it was generally considered likely that the organisms reached the wound except by direct transfer brought about by contamination of the hands, instruments, or supplies.

Approximately four years ago, because of the occasional severe infection in large operative wounds necessarily accompanied by some trauma and inadequate hemostasis, we studied carefully by bacteriologic cultures every step in the preparation of supplies and in the actual operative procedures. We found no source for the infections. If organisms could be cultured from the skin of the patient or the hands of the operating team, in the presence of perspiration, they were usually white staphylococci, while most of the infected wounds showed a pure culture of the hemolytic *Staphylococcus aureus*. The severe infections were also much more common during the winter months when there was the least danger of contaminating the wound with infected perspiration.

from reaching the rooms. All persons entering the operating rooms at any time wore the conventional, but totally inadequate, mask. Cultures from the walls and ceilings showed staphylococci to be present. The walls and ceilings were repainted, and the floors and walls were washed frequently in order to eliminate this source of contamination. Following these measures, the room so treated was almost free of organisms until it was occupied for the first operation, at which time the air contamination immediately rose. The operating room shoes, uniforms, blankets, sheets, and other supplies were free of staphylococci except for an occasional colony obtained from the shoes. These were no more numerous than from the other objects exposed to the air in the same room. The air in the operating room, which was in almost continual use, was found to be more highly contaminated than the air at any place cultured in the hospital or medical school. The degree of contamination at any place seemed to be directly proportional to the number of people present and the duration of occupancy.

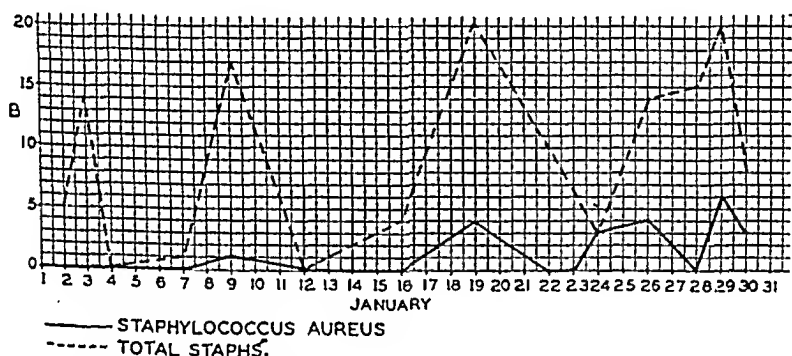


Fig. 4.—Graph plotted similar to Fig. 3, showing a period of extremely low contamination of the air of an operating room during occupancy. It is only rarely that we have a period when the total contamination with staphylococci is so low, but there are many times when a *Staphylococcus aureus* is only occasionally found. During such periods, large operations can be performed with much greater safety than during the period represented in Fig. 3.

It was then determined that at that time, during the winter months, from 65 per cent to 85 per cent of the operating room personnel, as well as the general population, were carriers of the *Staphylococcus aureus* (frequently hemolytic) in their noses and throats (Fig. 7). During the following summer, the percentage of carriers dropped below 20 per cent. In any room, given the same degree of occupancy, it was found that the air contamination with the *Staphylococcus aureus* varied directly with the number of carriers of this organism in their noses and throats. The danger of infecting a given wound seemed to depend on the degree of air contamination which in turn depended on the number of carriers. Even with such a high percentage of carriers of the *Staphylococcus aureus*, it was thought wise to eliminate all of them from certain rooms to be used for operations, such as thoracoplasties,

As soon as a Petri dish of blood agar was exposed to the air in the operating room, the source of our infections was evident. Invariably large numbers of organisms, predominantly staphylococci (albus and aureus) settled out of the air. (Figs. 1 and 2.) Infections with the *Staphylococcus aureus* usually occurred when the air contamination with this organism was greatest. Cultures were taken daily, and a continuous graph was plotted in an attempt to anticipate the periods of greatest danger. During these periods of high contamination (Fig. 3), all operations having a wound highly susceptible to infection (thoracoplasties, radical mastectomies, etc.) were postponed to a time when the air contamination was low (Fig. 4). Infections were reduced but not eliminated by these measures, since the air was never free of organisms.

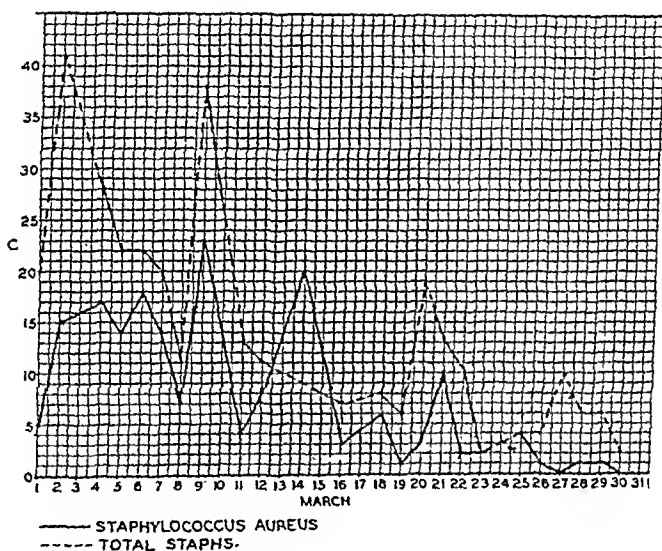


Fig. 3.—Graph showing the number of staphylococci cultured from the air in an operating room during occupancy during the month of March. Each point on the graph represents the number of colonies dropping out of the air on a sterile Petri dish of blood agar during one hour of exposure. For our operating rooms, this contamination during the first half of the month was considered to be quite high, particularly for the *Staphylococcus aureus*, which is more likely to grow if it gains entrance to a large wound. The total bacterial count here was quite low and was obtained only by ventilating the room with washed and filtered air, painting and washing the room, limiting the number of occupants, and masking at all times.

At the time it was felt that the organisms were brought into the operating rooms from the other parts of the hospital by air currents. The incoming air, which had been washed and filtered, but not cooled or dehumidified, was found to be practically sterile (Fig. 5) even though the outside air contained many organisms, mostly nonpathogenic (Fig. 6). Double doors were installed to prevent air currents between the wards and operating rooms, the ventilating system was run so as to bring in large quantities of clean air and allow it to escape through the cracks around doors, thus hoping to prevent infected air

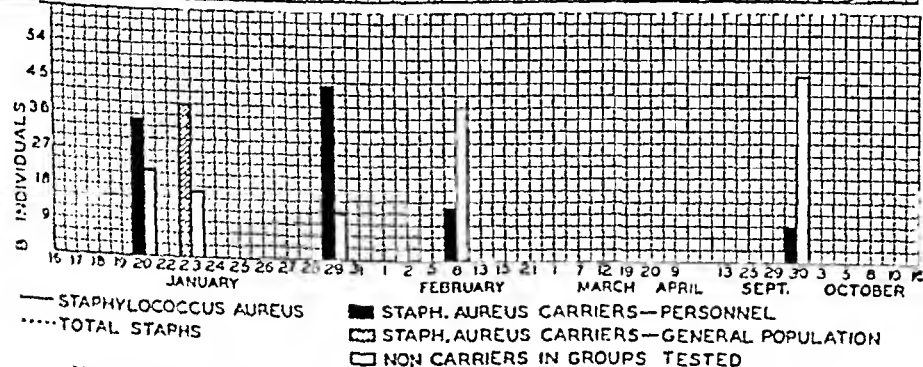
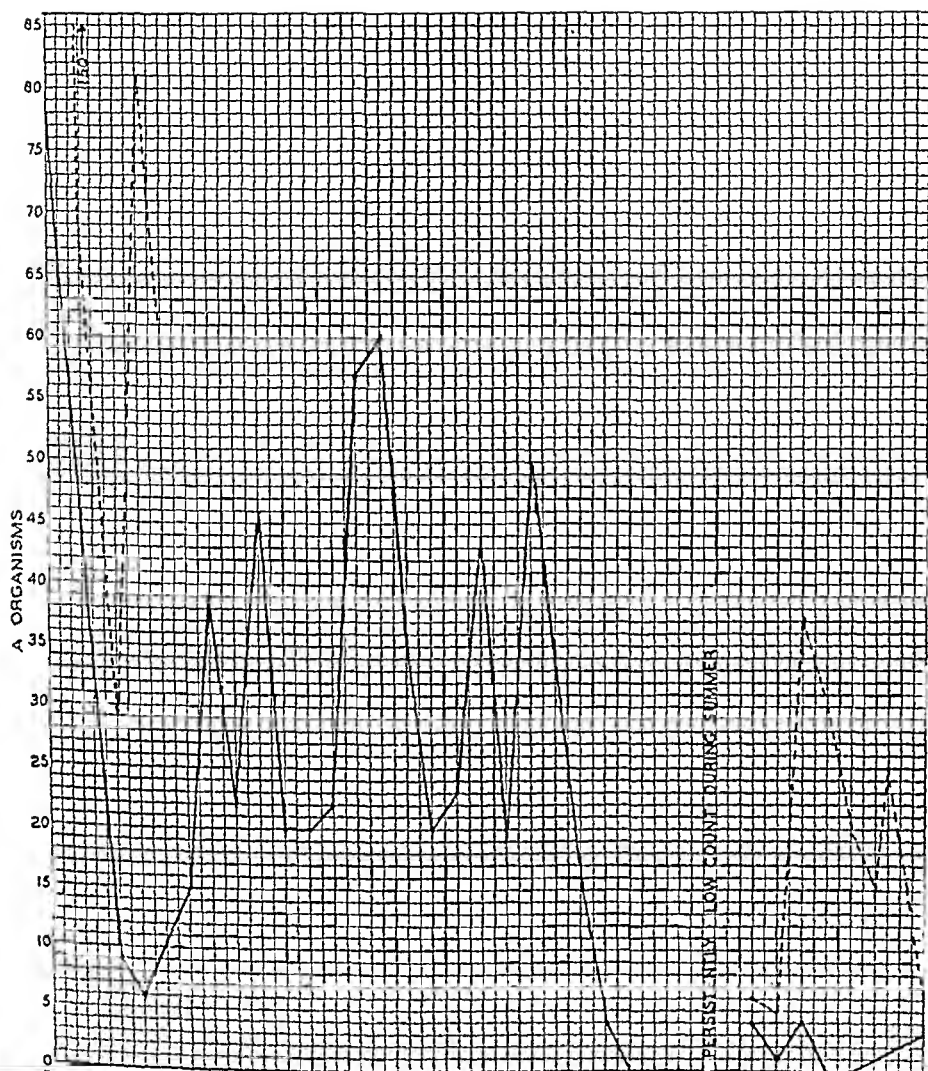


Fig. 7.—The number of colonies of *Staphylococcus aureus* cultured from the air was apparently determined by the number of carriers present. The upper part of the chart shows the number of colonies of *Staphylococcus aureus* settling out of the air on a Petri dish during an hour's exposure. During this time, rigid regulations to reduce the air contamination had not been put into effect, and the significance of the carriers was being determined. The lower part of the chart shows the number of carriers and noncarriers in the operating room personnel and in the general population as determined by cultures of the nose and throat.

radical amputations of the breast, nephrectomies, arthroplasties, Cesa-rean sections, or other large procedures. This was found to be impractical since the nose and throat cultures changed from day to day, many of the carriers apparently not having the organisms in their noses and



Fig. 5.—The air coming into the operating room was practically sterile on repeated examinations. This Petri dish of sterile blood agar was exposed for one hour and cultured for forty-eight hours.

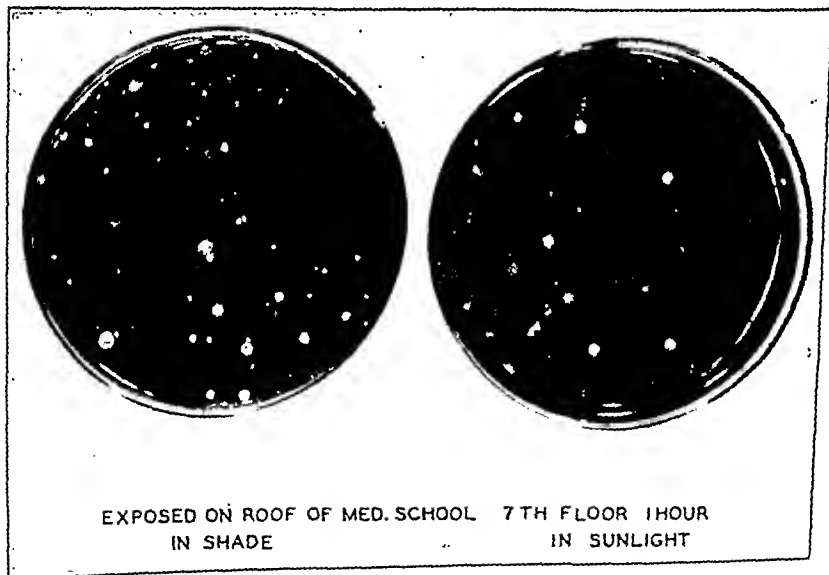


Fig. 6.—Petri dishes of sterile blood agar exposed on the roof showed many organisms. These were predominantly molds and spore-forming organisms. This contamination was eliminated by the air-conditioning apparatus (see Fig. 5). The air in the operating room was recontaminated by the occupants, the staphylococci predominating (see Figs. 1 and 2).

throats continuously. All persistent carriers, however, were eliminated; masks were worn *at all times*; and everyone in the operating room during operations wore two masks. No visitors were allowed; large opera-

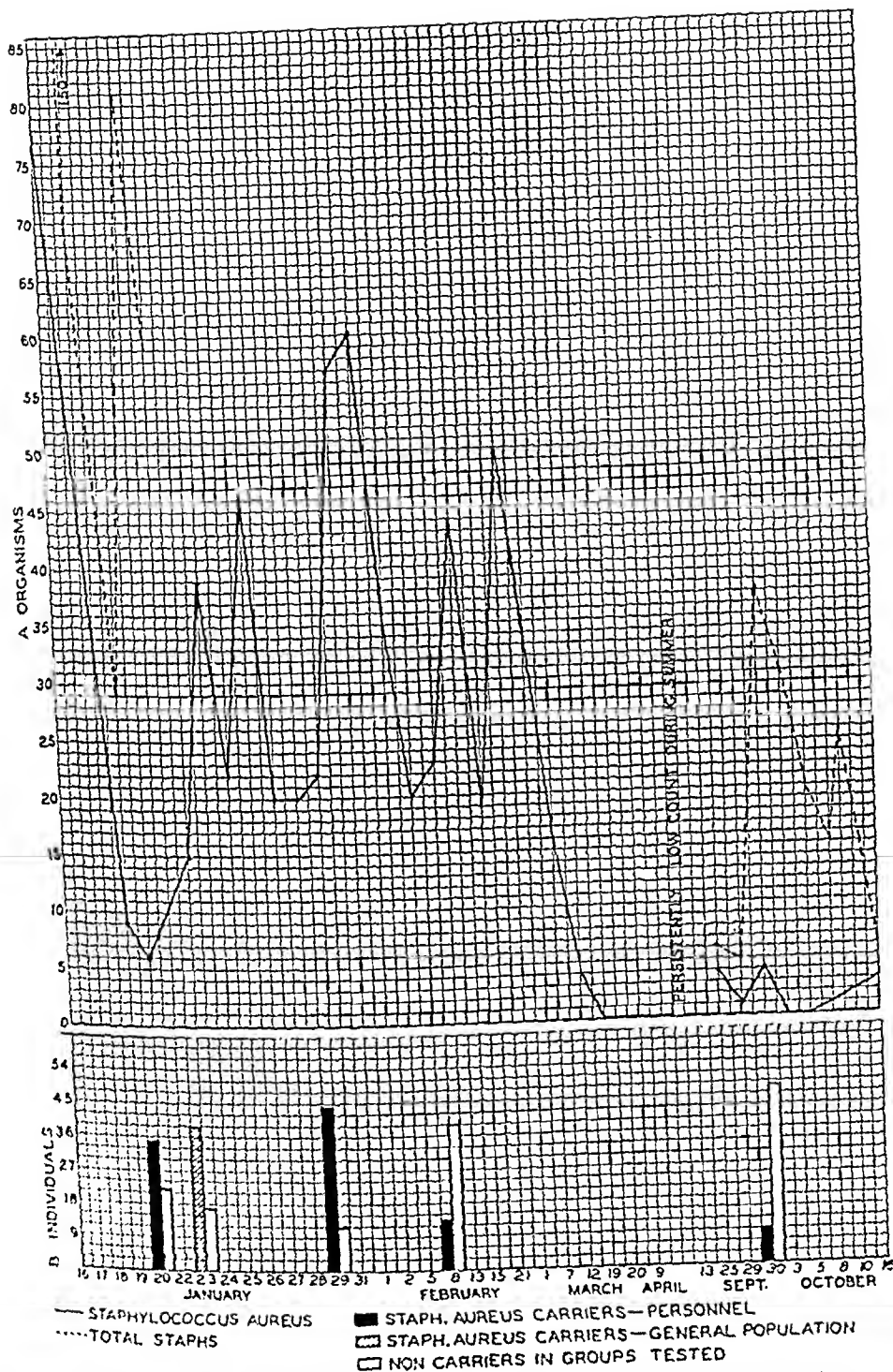
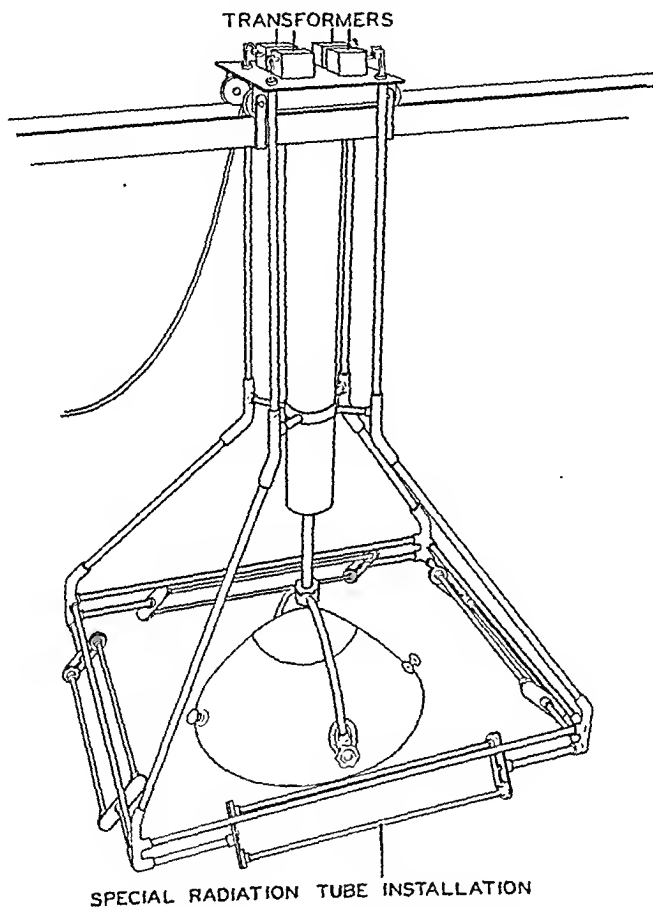


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tions were performed only as the first cases in the morning when the air was least contaminated; and the ventilating fans were run continuously to dilute the contaminated air. With these measures the air contamination was reduced, but not to such a level as to eliminate infections.

Since we had shown that the contamination must come from individuals present (operating personnel or patient), and since these could



SPECIAL RADIATION TUBE INSTALLATION

Fig. 8.—The radiation tubes were mounted about the operating room lamp as shown, the opposite tubes being placed five feet apart. This installation was used for the following reasons:

1. No object near the wound could block all the radiation.
2. Bacteria given off by the operating team would be killed since they would be in the area of most intense radiation.
3. A barrage of bactericidal radiation would be laid down which would kill all bacteria in the air before they could float into the operative field and drop into the wound.
4. Since the radiation tube mounting moves with the operating room light, the operative incision is always directly beneath the center of the radiation.

not be eliminated, or contamination of the air prevented, we felt that some method of sterilizing the air was the only means of eliminating

this great source of danger to the patient. We turned to radiant energy known to have bactericidal properties as offering the best chance of accomplishing the desired results. A therapy ultraviolet light was shown to be capable of destroying a sprayed culture of *Staphylococcus aureus* at a distance of eight feet within sixty to ninety seconds. A radiation device was designed and constructed by the Westinghouse Lamp Company to give the maximal bactericidal radiation and the minimal erythema action on the patient. These devices are tubular in shape, have unheated electrodes, and are filled with a mixture of

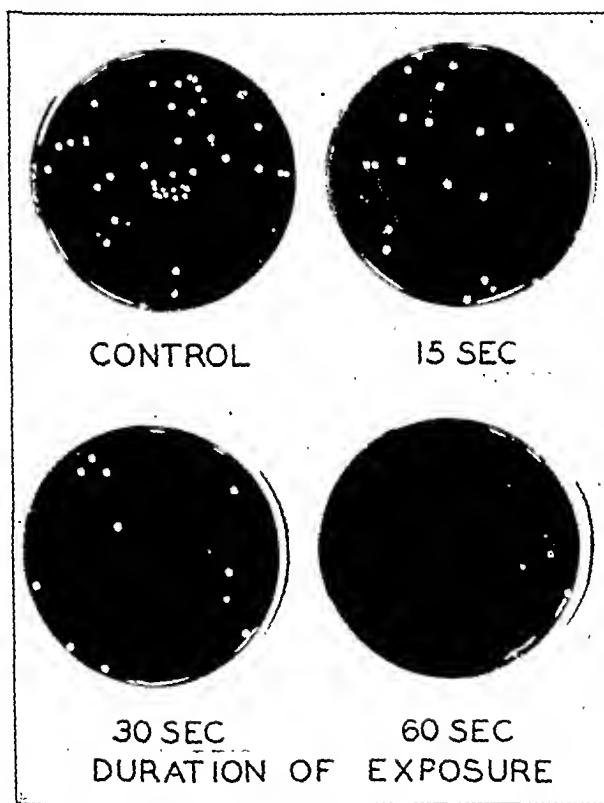
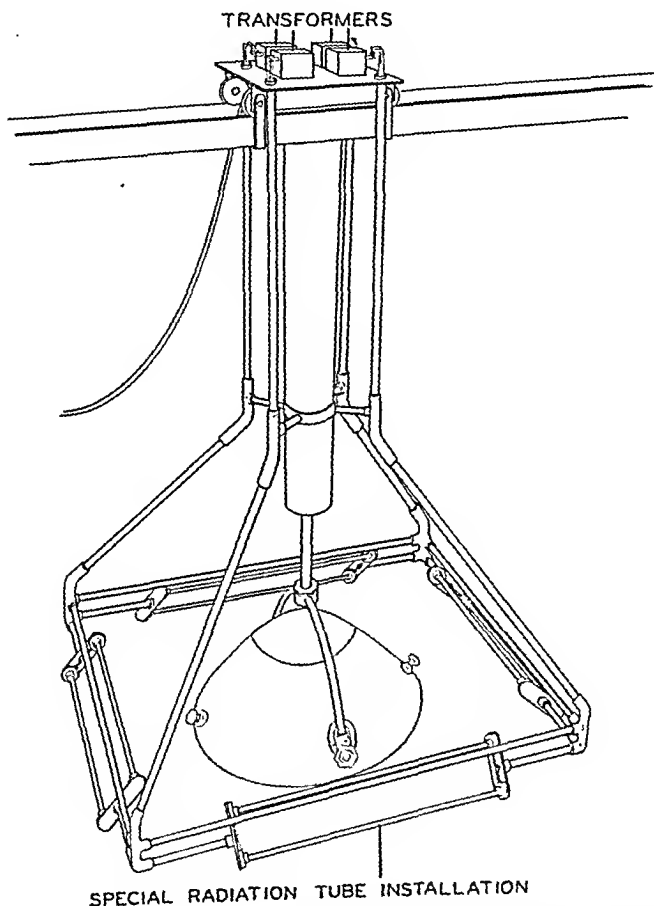


Fig. 3.—Petri dishes of blood agar, sprayed lightly with a filtered suspension of hemolytic staphylococci, were practically sterilized within sixty seconds when exposed to the radiation in the approximate location of an operative incision, five feet below the center of the tube mounting.

gases in which the discharge takes place with the production of radiant energy having a high bactericidal and a low erythema effect. The tube itself remains at a temperature only a few degrees above room temperature, and there is no objectionable production of ozone. Eight of these tubes were mounted as shown in Fig. 8 at a position so that each tube was approximately five feet from the operative incision. Blond volunteers were exposed at this distance for as long as eighty minutes without more than a slight redness and prickling sensation

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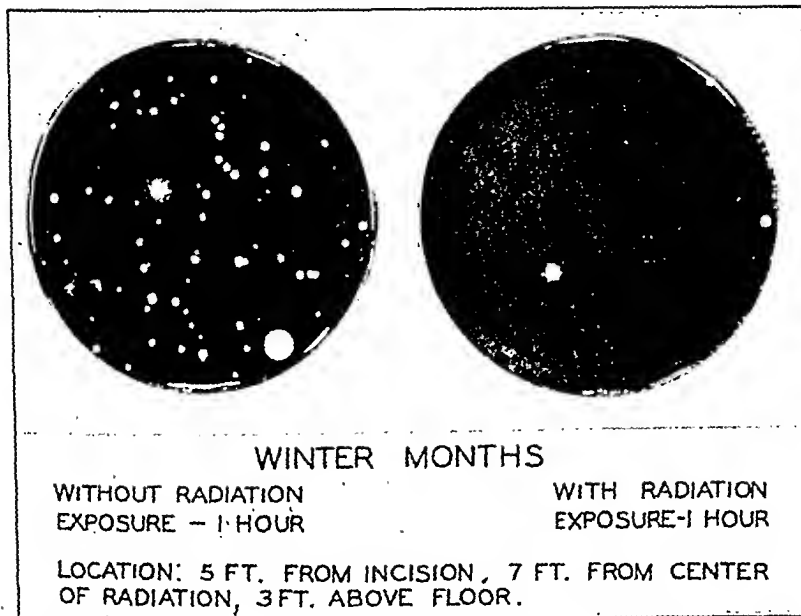


Fig. 11.—Petri dishes of sterile blood agar exposed during the winter to the air for one hour during an operation in a location five feet from the incision, three feet above the floor, and seven feet from the center of the radiation tube mounting. The exposure without the radiation was made first, while the exposure with the radiation was made during the following operations at which time with longer occupancy the air contamination should have been greater. Only two colonies are present in the Petri dish exposed to the radiation, and one of these is near the periphery where it may have been shaded and protected.

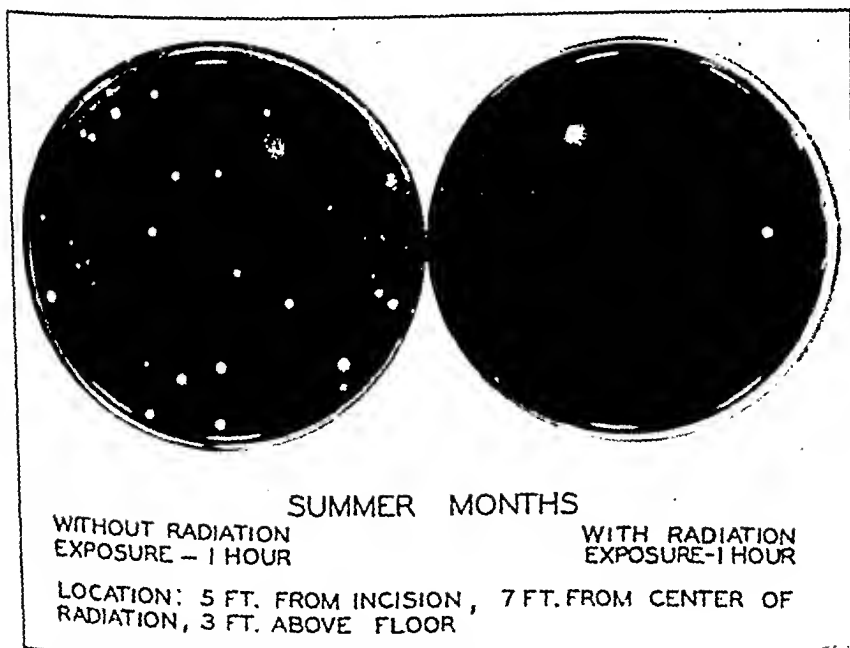


Fig. 12.—Sterile Petri dishes of blood agar exposed during the summer in the same manner for the same duration and at the same location as those shown in Fig. 11 which were exposed in the winter. Note the diminished air contamination during the summer (compare Fig. 11). The effectiveness of the radiation in destroying the bacteria in the air is shown, since there is only one colony of staphylococci on the plate exposed to the radiation even at a distance of seven feet.

in the skin which disappeared within twenty-four hours. Lightly sprayed cultures of a filtered suspension of hemolytic *Staphylococcus aureus* were killed at this distance within sixty seconds (Fig. 9), while heavily sprayed cultures were killed within less than five minutes (Fig. 10). Many types of bacteria were exposed with uniformly rapid death to practically all the organisms.*

Sterile culture plates exposed to the air for one hour within six to eight feet of the radiation tubes showed only an occasional organism, whereas the plates similarly exposed the preceding hour showed many colonies (Figs. 11 and 12). It was felt that we were laying down a barrage of radiant energy about the operative wound which would

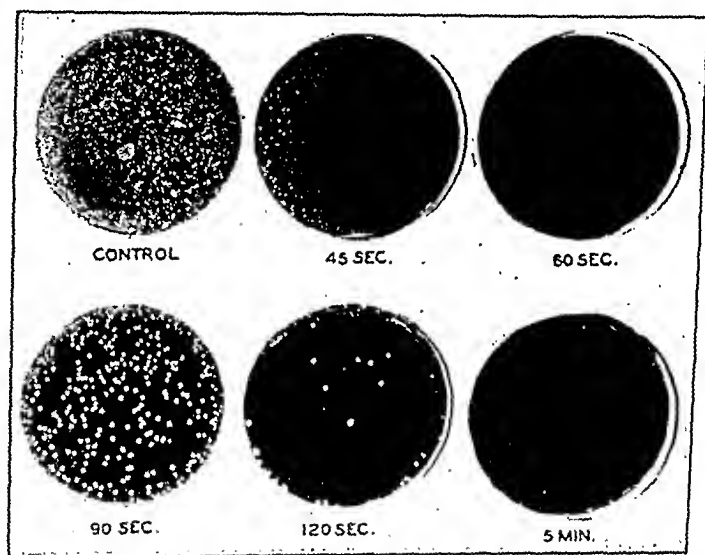


Fig. 10.—Petri dishes of blood agar, sprayed heavily with an unfiltered suspension of hemolytic staphylococci, were practically sterilized within less than five minutes when exposed to the radiation five feet below the center of the mounting. As can be seen, most of the colonies in the center of the Petri dish were killed within two minutes, while about the periphery the organisms which were shaded from part of the radiation survived this exposure in larger numbers. With an unfiltered suspension, the organisms were in clumps and also with a heavy inoculation, part of the organisms were more likely to be partly shaded by other organisms and therefore survived for a longer period of time than in Fig. 9.

kill not only all organisms floating in from the surrounding air, but any which might be given off by the individuals in the operating rooms.

Wounds in animals† were exposed for as long as ninety minutes at a distance of five feet from the eight tubes. The skin, subcutaneous tissue, muscle, and peritoneum seemed to heal as well as, if not better than, where the radiation was not used. There was no increase in

*Cultures were made by John Devine, who is working with me on the effect of this radiation of various organisms. To be published.

†Experiments carried out with Paul W. Sanger. To be published.

was not used. This may be partly or completely accounted for by the elimination of bacterial contamination, or there may be some stimulating effect to the radiation. Only one patient has developed an unexplained infection in a clean operative wound. No member of the operating room personnel has received a burn. It has been increasingly difficult to impress on them the need for adequate protection, since the radiation appears to be so harmless. A few have had a prickling sensation in the skin for a few hours, and one nurse who remained close to the radiation tubes for some time without glasses or other protection for the eyes developed a conjunctivitis which cleared up within twenty-four hours.

Extrapleural paravertebral thoracoplasties were taken as the best type of operation to prove the efficacy of the radiation in preventing wound infection or severe contamination. These wounds have a large exposed area; there is always considerable trauma; hemostasis at best is imperfect; and closure of all layers except the skin has been made with continuous catgut. These wounds, therefore, offered a favorable site for the growth of any pathogenic organisms which might gain entrance. Before beginning the use of bactericidal radiation, an occasional severe infection forced us to insert drains, while after beginning the use of this radiation, the insertion of drains was soon discontinued as there was little drainage or reaction in the wound, and cultures of the drains on removal showed no growth. Comparative results as shown in Table I indicate that bacterial contamination of these wounds has been greatly reduced if not eliminated in the majority of operations.

TABLE I
EXTRAPLEURAL THORACOPLASTIES FOR PULMONARY TUBERCULOSIS

TIME OF OPERATIONS	WITH RADIATION JAN., 1936 TO OCT., 1936		WITHOUT RADIATION MOSTLY IN SUMMER, 1930-1935, SINCE EXPERIENCE HAD SHOWN THAT WITH HIGH AIR CONTAMINATION IN WINTER, INFECTION WAS MORE LIKELY TO OCCUR	
	%	(NUMBER)	%	(NUMBER)
Total operations		(43)		(110)
Infections	4.5	(2)	33.0	(36)
Total deaths	2.3	(1)	5.5	(6)
Deaths from infection in wound		(0)	3.6	(4)
Postoperative temperature above 100.4° F. (38° C.)	45.0	(20)	68.0	(75)
Postoperative temperature for longer than 4 days	45.0	(20)	78.0	(86)

The radical mastectomies, like the extrapleural thoracoplasties, have inevitable trauma and a large exposed area during operation and in our hands have been closed with catgut. Although the group of cases

the number of peritoneal adhesions following exposure of the viscera. The brain and spinal cord were likewise exposed without subsequent demonstrable neurologic disturbances.

A protection was devised for the operating room personnel consisting of a hood of starched cloth over the head, face, and neck with goggles of plain glass to protect the eyes. It was necessary to maintain suction beneath the goggles to prevent fogging. This protection was at times supplemented by an eyeshade or a tropical sun helmet. The gown and gloves apparently give sufficient protection to the skin covered.

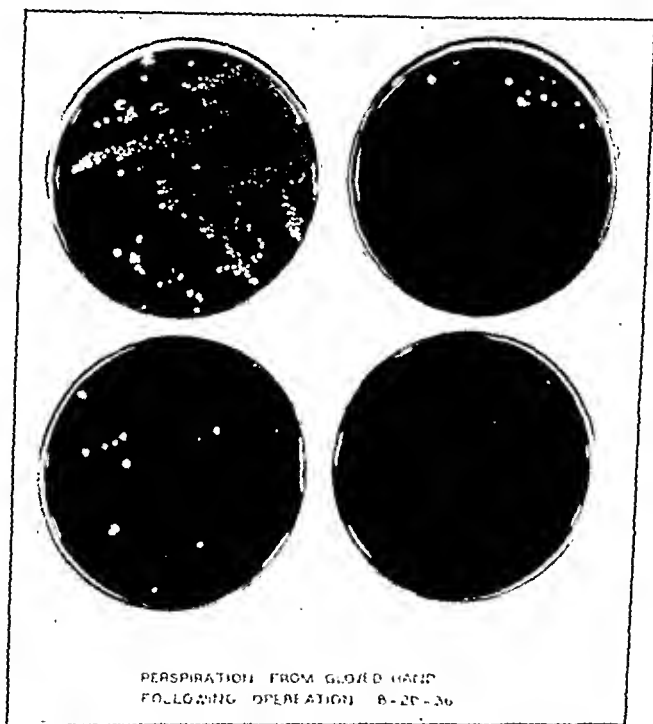


Fig. 13.—Perspiration, either on the skin of the patient or the operating team, is a distinct hazard in the operating room. The four culture plates are from the hands of the four members of the operating team on a very hot day. Cultures of the hands before operation showed no growth. Cultures at the end of the operation showed only *Staphylococcus albus*, the numbers of colonies on repeated cultures on different days being directly proportional to the amount of perspiration present. These organisms must have been washed out from the glands and hair follicles where they cannot be removed by scrubbing or killed by the use of antiseptics. We have no assurance that the *Staphylococcus aureus* may not occasionally be present. A torn glove, a damp gown, or the patient's wet skin may allow the organisms to get into the wound.

Over 200 operations have been performed on patients with uniformly great improvement in the postoperative course. In no case has a patient received a burn, and no patient has complained of the prickling sensation in the skin which comes from long exposure. Wound healing has been better as a whole than in those cases where the radiation

feeted. During this same period, in cases when radiation was not used, there were several mild infections, and one craniotomy incision, for an inoperable glioma, became infected with the *Staphylococcus aureus*. The latter patient died as a result of infection.

Among the group of over 200 operations performed in a field of air sterilized by bactericidal radiation, there were four clean operative wounds, all extrapleural thoracoplasties, in which infection was suspected. However, there was only one unexplained infection. The four cases are given briefly for the purpose of a complete report.

CASE 1.—The patient had a large hematoma which became infected. The portal of entry of the bacteria was unaccounted for, possibly from the air, or possibly from an unrecorded tear in a glove, or by way of the blood stream.

CASE 2.—The patient developed a mild infection which the surgeon who operated accounted for by a "large rent" in his glove with gross soiling of the wound with the perspiration which accumulated on a very hot day (Fig. 13). In an attempt to remove this, the wound was irrigated with a large amount of physiologic salt solution, but this irrigation did not prevent the infection.

CASE 3.—Following the third stage of a thoracoplasty, the patient developed a small area of skin necrosis as a result of cutting off too much of the blood supply to the skin flap. The temperature did not go up until after the fifth day; organisms were cultured from the necrotic skin; sutures were removed from this area alone, with rapid subsidence of the temperature and healing. The remainder of the wound was free of infection.

CASE 4.—The patient ran a high temperature following operation, and the incision was first explored with a probe and later opened under anesthesia. No pus was found; the wound did not appear to be infected or subsequently show signs of suppuration. A *Staphylococcus aureus* grew out of the culture taken when it was opened, some time after the insertion of the probe. It soon developed that the temperature was caused by an extension of the tuberculous process to the good lung. This was confirmed by x-ray examination and prevented a continuation of the collapse by thoracoplasty.

The tables quite strikingly show the great reduction in the number of infections where the operation is performed in a field of bactericidal radiation. The lower postoperative temperature elevation and its much shorter duration following operation are evidence that there was a diminution in the bacterial contamination in those wounds which ordinarily do not go on to suppuration. This reduction in the postoperative temperature in clean cases suggests that much of the elevation which we ascribe to absorption of blood and traumatized tissue in clean wounds, or to increased absorption of tuberculin in thoracoplasties, is really caused by a bacterial infection which does not progress to the stage of suppuration. Equally as striking as the objective improvements noted in the tables were the symptomatic improvements in the postoperative course where radiation was used. The patients complained less of pain and soreness in the wound; the general systemic reaction was less severe; healing was more rapid; and convalescence was less stormy than in the patients operated on without the use of the bactericidal radiation.

is smaller than for the thoracoplasties, they are given in Table II. This also shows the great improvement in results in the postoperative course of the patients operated on in the field of air sterilized by bactericidal radiation.

TABLE II
RADICAL MASTECTOMY

TIME OF OPERATIONS	WITH RADIATION		WITHOUT RADIATION	
	JAN., 1936 TO SEPT., 1936		JAN., 1935 TO SEPT., 1936	
	NO INFECTION	INFECTION	NO INFECTION	INFECTION
Number of operations				
Nonulcerated	8	0	12	3
Ulcerated	2	1	0	1
Total	10	1	12	4

	WITH RADIATION		WITHOUT RADIATION	
	%	(NUMBER)	%	(NUMBER)
Postoperative temperature above 38° C.	36	(4)	44	(7)
Postoperative temperature elevation for longer than 4 days	27	(3)	41	(7)

The inguinal herniae were selected as a group of clean operative incisions having a smaller size and less trauma than either the thoracoplasty or radical mastectomy group. Even in these cases there was a striking improvement in the results as shown in Table III. It was not appreciated by any member of the staff that we had as many infections (all of them mild) in these cases where the bactericidal radiation was not used. Since it was felt that there was little danger of infection in a small incision of this type, only sixteen were operated upon with bactericidal radiation. In general, the large hernia, in the more obese patient, was operated upon with the radiation, since it was felt that infection was more likely to occur in these cases.

TABLE III
INGUINAL HERNIAE
(INDIRECT AND DIRECT)

TIME OF OPERATIONS	WITH RADIATION		WITHOUT RADIATION	
	JAN., 1936 TO SEPT., 1936		JAN., 1935 TO SEPT., 1936	
	%	(NUMBER)	%	(NUMBER)
Total operations		(16)		(109)
Number of infections		(0)	4.6	(5)
Number of deaths		(0)		(0)
Postoperative temperature above 38° C.	25	(4)	37	(40)
Postoperative temperature elevation for more than 4 days	25	(4)	55	(60)

Of the remaining patients operated on under the bactericidal radiation, consisting of laparotomies, postoperative herniae, femoral herniae, lamineectomies, craniotomies, thyroidectomies, etc., no case became in-

PAPAIN AND PERITONEAL ADHESIONS

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IN A recent paper, Ochsner and Storek¹ reported 231 collected cases in which papain had been used to prevent the re-formation or initial formation of peritoneal adhesions. Clinical results were obtainable in 224 of their cases, and of this total, 88.8 per cent were classified as satisfactory. Their article, however, fails to give statistics on a similar series of cases in which papain was not employed, and consequently the evaluation of their results is difficult.

It is not the purpose of this paper to discuss the properties of papain. For information on this subject, the reader is referred to the excellent articles of Ochsner and Storek,¹ Ochsner and Garside,² and Walton.³ Suffice it to say, however, that papain is a vegetable ferment and is capable of dissolving fibrin.

Through the kindness of Dr. Ochsner, who has kept us supplied with the drug, we have been able to use papain in many of our cases of peritoneal adhesions during the past four and one-half years. On his recommendation, we have used papain in dilutions of 1:20,000, it being our practice to dissolve 50 mg. of the drug in 1000 c.c. of mammalian Ringer's solution. By and large, the amount used in each case has averaged in the neighborhood of 500 c.c., as it has been our experience that the peritoneal cavity would rarely hold more than this amount. In every instance in which papain was employed, it was used to prevent the re-formation of adhesions divided at the time of operation, and in no case was it used solely in a prophylactic sense, i.e., to prevent the initial formation of adhesions.

MATERIAL

A total of 72 cases are reported here. These represent patients upon whom division of peritoneal adhesions was performed at the Presbyterian Hospital between January 1, 1932, and January 1, 1936. No case has been included with a follow-up of less than six months' duration. Six of the cases were subsequently reoperated upon.

Papain was used in 34 out of the 72 cases (or in 47.2 per cent of the entire group) and at reoperation in 2 out of 6 instances. No papain was employed at the initial operation in 38 cases (52.8 per cent of the entire group), and it was omitted at reoperation in 4 out of 6 instances.

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SUMMARY AND CONCLUSIONS

1. The air in any closed space, as in an operating room occupied by human beings, is highly contaminated with pathogenic bacteria, as can be demonstrated by exposing a suitable culture plate to the air and incubating it at body temperature.
2. Human beings are the source of the air contamination. The usual operating room mask is inadequate.
3. Most of the operating room infections are caused by organisms similar to those floating in the air and recovered on exposed culture plates.
4. Since these pathogenic organisms floating in the air are predominantly staphylococci, and since the skin is known to be highly contaminated with these organisms, the wound infections have usually been ascribed to contamination from poor skin technique, while the air has been ignored.
5. Bactericidal radiant energy is almost 100 per cent efficient in killing the organisms floating in the air in the operative field at a distance of five feet from the source of radiation, while it is over 80 per cent efficient at distances of eight to ten feet.
6. This radiation will not blister a blond at five feet within eighty minutes; in a series of over 200 operations, no patient has been burned, and there has been no demonstrable damage to the tissue exposed in the wound.
7. With adequate protection, no member of the operating room personnel has received a burn.
8. There is not an appreciable amount of ozone formation.
9. By the use of this radiant energy, operating room infections have been greatly reduced; the postoperative temperature in supposedly clean cases has been lower and of shorter duration; there has been better healing; and the patient has had less postoperative discomfort.
10. It is our opinion that without bactericidal radiant energy to sterilize the air, every wound is highly contaminated with pathogenic bacteria. Avoidance of unnecessary trauma, tension, and strangulation of tissue, meticulous hemostasis, and the use of silk will go far toward preventing these organisms from gaining a foothold. Such technique, however, cannot be relied upon to produce such an unfavorable field that these organisms will in no case grow and cause suppuration. *It is far better to prevent the entrance of organisms into the wound.* The best surgical technique still should be used. Silk as the least irritating, most easily sterilized, smallest volume, and most satisfactory, *but non-absorbable* ligature and suture material can be buried in the wound with greater confidence when the air, our greatest source of wound contamination at the present time, has been rendered free of viable pathogenic bacteria.

TABLE II
INDIVIDUAL INCIDENCE OF PREVIOUS OPERATIONS

NO. OF PREVIOUS OPERATIONS	NO. OF PAPAIN CASES PERFORMED ON	NO. OF CONTROL CASES PERFORMED ON
1	21	28
2	7	6
3	3	2
4	0	0
5	0	1
0	3	1

TABLE III
PREVIOUS OPERATIONS

TYPE OF OPERATION	NO. PERFORMED ON PAPAIN CASES	NO. PERFORMED ON CONTROL CASES
Division of adhesions	7	7
Appendectomies	16	21
Pelvic procedures	9	14
Gallbladders	4	1
Herniorrhaphies	1	1
Enterostomies	3	4
Resections	3	2
Drainage peritoneal abscesses	1	1
	44	51

EXTENT OF ADHESIONS

The extent of adhesions found at operation was mentioned in all but one case (one in which papain was employed). For simplicity's sake we have employed the terms: few, moderate, and many or massive to designate their extent, the distinction being a purely arbitrary one and often difficult to determine from the operative notes. It will be seen from Table IV that among those in the papain group in which it is mentioned, the adhesions were few in number in 10 cases (30.3 per cent), moderate in 18 cases (54.6 per cent), and many or massive in 5 (15.1 per cent). In the "no papain" group, they were few in 17 instances (44.8 per cent), moderate in 16 (42.1 per cent), and many or massive in 5 (13.1 per cent). From this it would appear that by and large the adhesions were more extensive in those cases in which papain was used.

TABLE IV
INCIDENCE OF ADHESIONS

EXTENT	NO. OF PAPAIN CASES	PER CENT	NO. OF CONTROL CASES	PER CENT
Few	10	30.3	17	44.8
Moderate	18	54.6	16	42.1
Many or massive	5	15.1	5	13.1
Not mentioned	1		0	

SEX AND AGE

In the combined series of 72 cases, 54, or 75 per cent, were females, and 18, or 25 per cent, males, the ratio of females to males being exactly 3 to 1. This is a somewhat lower figure than that found in Ochsner and Storek's series in which the females outnumbered the males by slightly better than 5 to 1.

The youngest in our series was fifteen years of age, the oldest, seventy-two years. By actual count there were no cases in the first decade (the Presbyterian Hospital does not admit patients under the age of 13), 8 (11.2 per cent) in the second decade, 24 (33.3 per cent) in the third decade, 16 (22.4 per cent) in the fourth, 12 (16.6 per cent) in the fifth, 7 (9.6 per cent) in the sixth, 3 (4.1 per cent) in the seventh, and 2 (2.8 per cent) in the eighth. It will be seen that more than half of the cases (55.7 per cent) occurred in the third and fourth decades. Similar results were found in Ochsner and Storek's series, in which the percentage for the same two decades was 58.5.

TABLE I
AGE INCIDENCE BY DECADES

DECADE	NO. OF CASES	PER CENT
1st	0	0.0
2nd	8	11.2
3rd	24	33.3
4th	16	22.4
5th	12	16.6
6th	7	9.6
7th	3	4.1
8th	2	2.8

PREVIOUS OPERATIONS

Of the 34 patients upon whom papain was used, 31 had undergone previous operations. The total number of previous operations for this group was 44, giving an average of 1.4 operations for each patient previously operated upon. Of the 38 patients upon whom no papain was used, 37 had undergone 51 previous operative procedures. The average number of operations for each patient previously operated upon in this group was therefore the same as in the papain group, or 1.4. The greatest number of operations previously performed upon any one individual in the papain group was 3 and in the group without papain, 5. The actual numerical incidence of operations is shown in Table II.

As far as the types of previous operative procedures are concerned, it will be seen from Table III that in both series appendectomies were the most frequent, with pelvic operations second, and division of adhesions third.

free from adhesions" except in two places where adhesions which had been overlooked at the first operation were found. Division of adhesions and the instillation of another liter of papain were again done, and in addition a jejunostomy was performed. Two weeks later the patient died from inanition and a low-grade peritonitis. At necropsy the loops of gut in the peritoneal cavity were everywhere adherent to one another by a sticky fibrinous exudate; there were a few old adhesions, but there were no large collections of pus to be seen at any point.

The significance of this case lies in the fact that papain should probably not have been used at the second operation when a jejunostomy was indicated. We believe that the use of this drug is contraindicated in procedures involving enterostomy, for its fibrin-dissolving action may prevent the formation of protective adhesions about the enterostomy site and thus predispose to peritoneal infection secondary to leakage or contamination.

Among the cases here reported, there has been only one late mortality. This was apparently due to pulmonary tuberculosis and occurred seventeen months after operation in a case in which papain was not used. As far as is known, there were no further obstructive symptoms after operation. Unfortunately, an autopsy was not obtained.

RESULTS

We realize that symptoms from old adhesions, particularly from single bands, may occur many years after the probable date of their formation so that our results may be better than they will be at a later date. On the other hand, this may be offset in some cases by the well-known progressive absorption of adhesions.

In the papain group, excellent clinical results were obtained in 22 instances (64.9 per cent), and good results in 4 (11.7 per cent); in the "no papain" series, the results were classified as excellent in 23 cases (60.5 per cent), and as good in 10 (26.3 per cent). Satisfactory results, therefore, were obtained in 76.6 per cent of our papain cases and in 86.8 per cent of our control series. The results in 4 (11.7 per cent) of the papain group were termed fair, and in 4 other cases poor (11.7 per cent). In the control series, one case (2.6 per cent) was classed as fair, and 4 (10.6 per cent) as poor.

TABLE VI

RESULTS

	NO. OF PAPAIN CASES	PER CENT	NO. OF CONTROL CASES	PER CENT
Excellent	22	64.9	23	60.5
Good	4	11.7	10	26.3
Fair	4	11.7	1	2.6
Poor	4	11.7	4	10.6

FOLLOW-UP

Inasmuch as this is a study of late results, no cases which have not attended our follow-up clinic for at least 6 months have been included in this report. The longest follow-up in the papain group was 44 months, and the longest in the "no papain" group 51 months. The average follow-up for the 34 papain cases was 19.3 months, and that for the "no papain" group 20.6 months. From Table V it will be seen that 67.7 per cent of the papain group and 73.8 per cent of the group receiving no papain were followed for a year or longer; that 32.4 per cent of the former and 44.8 per cent of the latter were followed for 2 years or longer; that 14.7 per cent of the former and 10.6 per cent of the latter were followed for 3 years or longer; and that though no cases in the papain group were followed for 4 years, there was one case (2.7 per cent) in the "no papain" group followed for slightly longer than this time.

TABLE V
FOLLOW-UP (NONE UNDER 6 MONTHS)

MONTHS FOLLOWED	NO. OF PAPAINE CASES	PER CENT	NO. OF CONTROL CASES	PER CENT
6	1	2.9	3	7.8
7 to 11	10	29.4	7	18.4
12 to 17	8	23.5	10	26.3
18 to 23	4	11.8	1	2.7
24 to 29	2	5.9	7	18.4
30 to 35	4	11.8	6	15.8
36 to 41	4	11.8	2	5.2
42 to 47	1	2.9	1	2.7
48 to 53	0	0.0	1	2.7

UNTOWARD SEQUELAE IN THE USE OF PAPAINE

Ochsner states that high concentrations of papain may cause peritoneal irritation, but that the dilution of 1:20,000 which he advocates gives no demonstrable symptoms or signs. Our observations confirm this. In fact, we have to report only one untoward sequela which we believe might have been avoided. We have thought that theoretically, at least, papain should not be used in the presence of catgut suture material, for fear of a solution of the abdominal repair with a resulting disruption of the wound. Silk has therefore been employed for the repair in all cases but three, and no disruptions developed. One death occurred, however, which we attribute to faulty judgment in combining the use of papain with a jejunostomy.

The patient in question was admitted to the hospital with symptoms of chronic ileus. At operation a moderate number of adhesions were divided, a liter of papain instilled in the peritoneal cavity, and in closing the abdomen, a ventral hernia was repaired. Two weeks later, the persistence of obstructive symptoms necessitated a second laparotomy. At this operation the peritoneal cavity was reported to be "strikingly

SUMMARY

Seventy-two cases are reported upon which division of peritoneal adhesions was performed during a recent four-year period. In thirty-four of these papain was used in an attempt to prevent the re-formation of adhesions. In thirty-eight, papain was omitted. The cases, essentially similar in nature and operated upon by the same group of surgeons, are collectively analyzed from the standpoints of sex and age. Dividing them into "papain" and "no papain" groups, they are further analyzed with respect to the number and types of previous operations, extent of adhesions, follow-up untoward sequelae, and subsequent clinical results. In addition, the findings in six cases which came to reoperation are discussed.

We have purposely followed fairly closely the outline adhered to in Ochsner and Storek's recent report on this same subject, in order that the results set forth in the two papers may be the more easily compared.

CONCLUSION

While our figures do not indicate an appreciable improvement of follow-up results in the series in which papain was used, as compared with the series in which no papain was employed, we realize, as has been pointed out by Ochsner and Storek, that a long period of observation on a very large group of cases will be necessary before any definite conclusions concerning the efficacy of papain can be reached. We feel, in addition, that in reviewing this difficult group of cases the inclusion of a control series is essential to the proper evaluation of results.

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CASES REOPERATED UPON

There were six patients in the combined series who came to subsequent operation. Four of these received papain at their initial operations. In two of the latter, the adhesions at the first operation were so extensive that it was impossible to free them all. At reoperation no re-formation of adhesions was apparent and the recurrence of symptoms was thought to be due to adhesions left undivided at the original operation. Consequently the results in these two cases are inconclusive. One case receiving papain at the initial operation was said to be "extraordinarily free of adhesions" when reoperated upon later for a recurrence of symptoms. The fourth case in which papain was originally used also presented very few adhesions at reoperation. It appeared doubtful at the time, however, whether the adhesions had ever been responsible for the patient's symptoms in the first place. No definite conclusions, therefore, can be drawn from this case either.

Of the two cases receiving no papain at initial operation and later undergoing another laparotomy, there was a definite re-formation of adhesions in one. In the other, it was felt that the recurrence of obstructive symptoms was in all probability due to adhesions left behind at the first operation; apparently there had been little, if any, re-formation of adhesions.

COMMENT

It will have been noted that in general more satisfactory results were obtained in our "no papain" group than in our group in which this drug was employed, 86.8 per cent of the results in the former being classified as excellent or good as opposed to 76.6 per cent in the latter. This is of particular interest when we consider that Ochsner and Storek reported 88.8 per cent satisfactory results in their cases, in all of which papain was used.

Accounting for discrepancies in results either individually or collectively in cases of peritoneal adhesions is almost impossible, except in the broadest of generalities. Our figures would tend to indicate, however, that the adhesions in our papain group were somewhat more extensive than in our control group, 69.7 per cent of the adhesions in the former group being classified as moderate, or as many or massive, to 55.2 per cent in the latter. On the other hand, if we compare these figures with those given by Ochsner and Storek who reported the presence of extensive adhesions in 75 per cent of their cases, it would appear that the adhesions in their cases were in general more extensive than in ours. This makes it all the more difficult to reconcile their percentage of satisfactory results with papain (88.8) with ours (76.6), particularly when we consider that our results without papain (86.8 per cent satisfactory) closely approximate theirs in which the drug was used.

by gently moving the skin overlying the mass, and noting the point of attachment. The cyst should never be squeezed to find a suspected point of external opening.

The swelling may, in rare cases, lie behind the sternocleidomastoid muscle, but then other causes of neck swelling should be considered first.

When pressure symptoms are present, they usually take the form of a respiratory embarrassment. Recently, we observed a child aged six months with a large cyst in the right anterior triangle. The child had repeated attacks of severe cyanosis, stridulous breathing, and dyspnea. The attack had been relieved on several occasions by deep pressure on the cyst with the discharge of mucoid material from the external orifice. The attacks were precipitated by mild upper respiratory infections in which the mucous membrane of the pharynx evidently became swollen, blocking the internal opening, and causing the cyst to rapidly increase in size.

The most common complication is infection. The cyst becomes infected during an upper respiratory infection by direct continuity with the pharynx. When this occurs, the presenting lesion is an abscess in the anterior triangle of the neck. The neck is swollen, and the overlying skin is hot and usually of a violaceous color. The tumor is exquisitely tender, and the general constitutional symptoms attending an abscess will be present. The infection is rarely virulent, and a certain amount of conservatism may, therefore, be used in its treatment. If the abscess is widely incised, it will continue to drain over a long period of time, suggesting a tuberculous lesion to the clinician. All circumscribed abscesses of the anterior triangle of the neck in which broken-down lymph glands are excluded should, therefore, be viewed with a certain amount of suspicion of their being infected branchiogenic cysts.

As a rule, diagnosis is not difficult. In the complete, uncomplicated type, it may be confirmed by injection of a bland, colored solution, which will make its appearance at the internal ostium. Roentgenologic examination can be of great help. This is accomplished by the injection of a radiopaque substance into the cyst. Iodized oil, one of the many roentgenographic solutions, or bismuth paste may be used. The latter has the advantage of economy, but should only be used if surgical intervention is imminent. The removal of the paste is, however, difficult. One must be careful not to squeeze the cyst, since then the injected material may be forced through the internal opening and be aspirated.

The lesions which may be confused with a branchiogenic cyst in the infant are few and easily differentiated. The greatest difficulty may be found in the so-called cystic hygromata. These lymphoid cysts are, however, usually situated in the posterior triangle of the neck, and have neither internal nor external openings. Tuberculous and other

BRANCHIOGENIC CYSTS IN INFANCY

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BRANCHIOGENIC cysts are congenital anomalies, which are of interest and importance both from the clinical and embryologic standpoint. They may disturb some of the normal functions of the body, and occasionally they are of potential danger to the life of the patient. They are often minute in size and do not become evident until the later years of childhood, or they may even escape notice entirely until they undergo malignant changes. Their care in infancy, when they do become manifest, demands the specialized care which is required by a patient whose tissues are delicate and in a state of development.

To Hunezowski, in 1789, and Dzondi, in 1829, are credited the first descriptions of the lesion, but the embryologic significance was first recognized by Ascherson. Many authors since that time, however, have waged a scientific battle regarding the origin of the cysts. Prominent among the contributors to this question are His, Koelliker, Born, Kostanecki, Mileky, Piersol, von Lissner, and Wenglowksi. No attempt will be made to review these theories, except to state that the theory of Wenglowksi appears to have found the most widespread acceptance among modern authors. He contends that the cysts are dilatations of the persistent thymic duct, which arises from the third branchial cleft and descends toward the back of the sternum.

Clinically three types of branchiogenic cysts or fistulas must be differentiated: the complete type, which has both an external and an internal opening; the incomplete internal, which has only an opening into the pharynx; and the incomplete external, which has only an opening on the skin. The last of these is the one which is most frequently diagnosed, because the internal opening is often very small and difficult to locate.

The symptoms produced during infancy are of three types. The most significant of these is deformity. There is usually a soft, globular swelling, just anterior to the sternocleidomastoid muscle. If uncomplicated, the swelling will not be tender, but will fluctuate beneath the examining fingers. Only rarely will it be tense and firm. The overlying skin will often display a minute red dot, which may escape all but the most painstaking inspection. At other times, the external orifice will be widely patent, with a moist surrounding skin, and a thin brittle crust over it. The external orifice can sometimes be located

by gently moving the skin overlying the mass, and noting the point of attachment. The cyst should never be squeezed to find a suspected point of external opening.

The swelling may, in rare cases, lie behind the sternocleidomastoid muscle, but then other causes of neck swelling should be considered first.

When pressure symptoms are present, they usually take the form of a respiratory embarrassment. Recently, we observed a child aged six months with a large cyst in the right anterior triangle. The child had repeated attacks of severe cyanosis, stridulous breathing, and dyspnea. The attack had been relieved on several occasions by deep pressure on the cyst with the discharge of mucoid material from the external orifice. The attacks were precipitated by mild upper respiratory infections in which the mucous membrane of the pharynx evidently became swollen, blocking the internal opening, and causing the cyst to rapidly increase in size.

The most common complication is infection. The cyst becomes infected during an upper respiratory infection by direct continuity with the pharynx. When this occurs, the presenting lesion is an abscess in the anterior triangle of the neck. The neck is swollen, and the overlying skin is hot and usually of a violaceous color. The tumor is exquisitely tender, and the general constitutional symptoms attending an abscess will be present. The infection is rarely virulent, and a certain amount of conservatism may, therefore, be used in its treatment. If the abscess is widely incised, it will continue to drain over a long period of time, suggesting a tuberculous lesion to the clinician. All circumscribed abscesses of the anterior triangle of the neck in which broken-down lymph glands are excluded should, therefore, be viewed with a certain amount of suspicion of their being infected branchiogenic cysts.

As a rule, diagnosis is not difficult. In the complete, uncomplicated type, it may be confirmed by injection of a bland, colored solution, which will make its appearance at the internal ostium. Roentgenologic examination can be of great help. This is accomplished by the injection of a radiopaque substance into the cyst. Iodized oil, one of the many urographic solutions, or bismuth paste may be used. The latter has the advantage of economy, but should only be used if surgical intervention is imminent. The removal of the paste is, however, difficult. One must be careful not to squeeze the cyst, since then the injected material may be forced through the internal opening and be aspirated.

The lesions which may be confused with a branchiogenic cyst in the infant are few and easily differentiated. The greatest difficulty may be found in the so-called cystic hygromata. These lymphoid cysts are, however, usually situated in the posterior triangle of the neck, and have neither internal nor external openings. Tuberculous and other

lymphadenopathies, aberrant thyroid glands, and angiomas and blood cysts will cause the clinician but little difficulty. Dermoid cysts and tumors of the carotid body will usually be readily ruled out. An aneurysm can be recognized by its expansile pulsation. Rare lesions may be found in this region, such as the so-called multilocular branchiogenic cyst and Berger's polycystic tumors of the parathyroid glands.

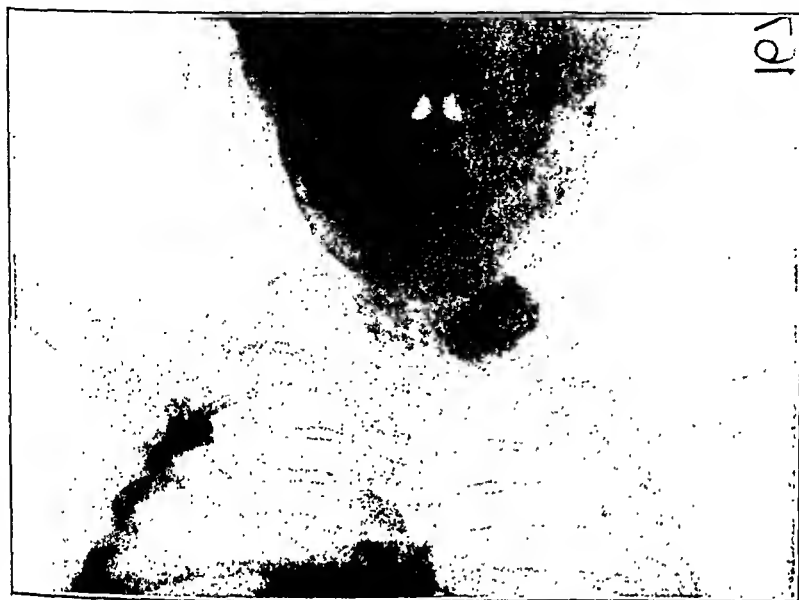
Treatment is dependent on the condition of the local lesion, the age of the patient, and the urgency of therapy. If the cyst is infected, conservatism should be the keynote wherever possible. The infections



Fig. 1.—Typical deformity of a branchiogenic cyst in an infant aged sixteen months. A, Front view; B, lateral view. (Note discoloration due to skin changes from a recent infection.)

are, as has been previously mentioned, usually of low virulence and cause but little systemic reaction. Hot moist dressings should be liberally applied and frequently renewed. These should be alternated with dry heat or alcohol-glycerine dressings to avoid maceration of the skin. In the application of these dressings, a word of caution must be interjected. A circular bandage around the neck should be avoided, as it may embarrass respiration. Should the infection be virulent, or spreading, the abscess must be incised widely enough to permit adequate drainage. As a rule, however, incision will not be necessary, and aspiration will suffice. This should be done with a

needle of fairly large caliber, and, if possible, through the external opening of the tract. Aspiration may be supplemented by irrigation, with a sterile isotonic salt solution. This is accomplished by first



A.



B.

Fig. 2.—X-ray films taken with the branchiogenic cyst filled with a radiopaque medium. A, Anteroposterior view; B, lateral view.

aspirating as much of the infected material as possible, and then gently instilling a small amount, two to five cubic centimeters of the

saline solution, and again withdrawing it. The entire aspiration or irrigating procedure should be practiced as infrequently as possible, to avoid the introduction of new contaminating organisms.

Such a regime usually will convert an infected cyst into the uncomplicated variety. The infection, in fact, may completely destroy the lining of the cyst and so effect a cure. Incision of the cyst almost invariably, however, introduces new infection and results in a badly scarred, draining fistula which is difficult to repair. In this type, repair should be delayed for a period of a month or more to insure

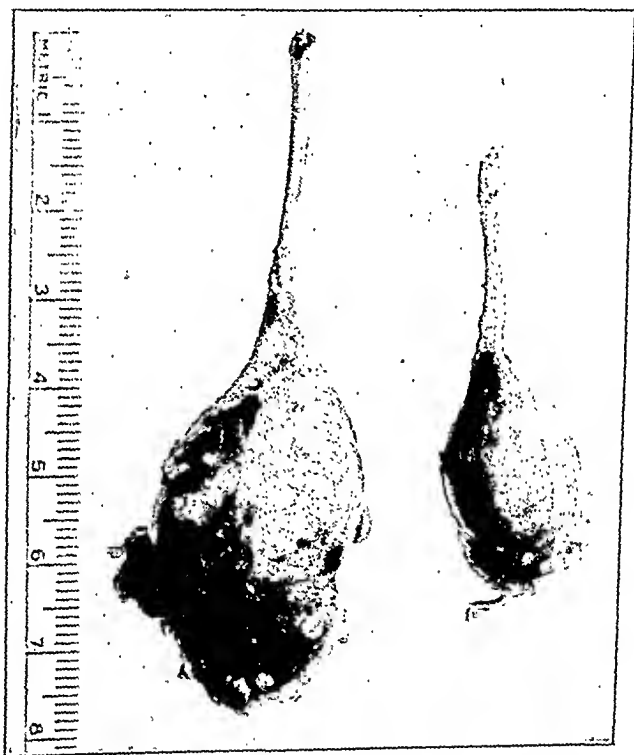


Fig. 3.—Operative specimen of a bilateral branchiogenic cyst removed from an infant aged eighteen months.

the absence of active infection. Bacterial counts may be of help in determining the progress of the treatment.

The simple cyst in the very small infant is technically somewhat difficult to remove, because the neck is very short and the anatomic structures are minute. The careful dissection necessary to separate the delicate structures in the infant is difficult. Therefore, unless the cyst is causing respiratory embarrassment, or becoming repeatedly infected, it is wise to postpone treatment until the infant has reached the age of one year, or, better yet, eighteen months. If the treatment is required

before that time, and the cyst has not been infected for at least six months, the injection of the cyst with an irritant material may be considered.

The injection of branchial cysts is probably an outgrowth of the similar form of treatment in brain cysts and in hydrocele. It has been favorably reported upon by several authors. Cutler and Zollinger report very favorable results with a modification of Zenker's solution, while others have used a variety of media. The injection is done

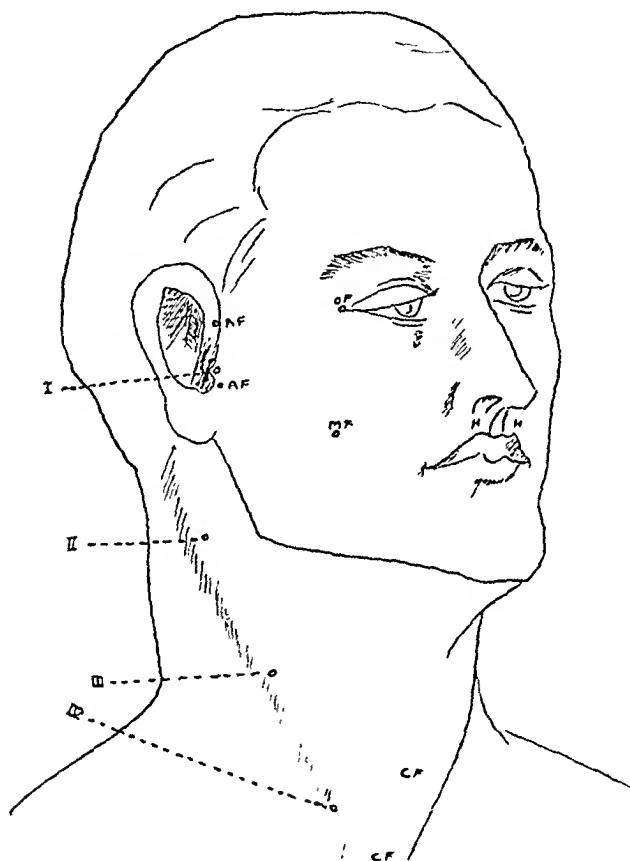


FIG. 1.—Drawing to illustrate anatomic location of the various congenital lesions about the head and neck (after Bland-Sutton in Kirmisson, *Lehrbuch der Chirurgie Krankheiten Angeborenen Ursprungs*).

I, II, III, and IV represent sites of branchial clefts: A F, site of congenital ear fistula; C F, stoma of median neck fistula; M F, intermandibular fissure; O F, orbital fissure; H H, harelip.

after the skin surrounding the site of injection has been adequately protected from the corrosive action of the material to be injected. This can be accomplished by several coats of either 10 per cent tannic acid, or the compound tincture of benzoin. We favor the latter, since it forms a splendid protective coating without itself affecting the underlying skin. The tract should not be distended too greatly by the

irritating medium, as this may occasion leakage into the pharynx. It is best to inject a rather small amount and to cover the entire area with a thick piece of gauze which has been generously coated with zinc oxide ointment, and fasten this in place with elastic adhesive. This pressure pad will produce collapse of the cyst.

The injection of the cysts should not be considered too lightly, since in an occasional case, a marked inflammatory reaction may be seen, and even a necrosis may occur. Leakage into the pharynx is also a complication which must be borne in mind.

The treatment of choice is the surgical extirpation of the entire tract. This can be carried out without too great difficulty, after the first year of life, when the infant is well able to stand a general anesthetic. The anesthesia of choice is open ether, which affords the greatest margin of safety and the maximum of flexibility in the infant.

The anatomic course of the tract must be carefully considered in planning the mode of the attack. From the fossa of Rosenmueller where the internal ostium is situated, the tract passes beneath the angle of the mandible and then outward and downward beneath the midportion of the posterior belly of the digastric muscle. It then passes below the facial and above the glossopharyngeal nerves to come into intimate relationship with the carotid artery and internal jugular vein. Senn has stressed this relationship as being of signal importance in the surgical attack. McNealy states that the level of the external opening is determined by the level of the constriction of the bony opening of the chest. As the tract is in relationship to the carotid artery, it also is in relation to the vagus nerve and its recurrent branch. It is evident that an incision should be planned to give good exposure at the most difficult part of the dissection, where the tract crosses the great vessels.

The commonly employed incisions are either planned to follow the tract and course along the anterior border of the sternocleidomastoid muscle, or are stepladder incisions as suggested by Hamilton Baily. His incision is made transversely at the level of the external ostium, and a second incision placed at the level of the bifurcation of the carotid artery. Both of these incisions follow the natural creases in the skin and give excellent exposure of the tract. In our opinion, a collar incision similar to that used for thyroidectomy gives both excellent exposure and the most ideal cosmetic result. In the somewhat rare bilateral cases, the incision is exactly similar to the collar thyroid incision, while in the unilateral cases the incision is not carried quite so far on the normal side. The incision is marked out by moving a piece of catgut on the skin at the lower portion of the neck. A hemostat is placed on the external ostium, and it is circumscribed. The flap is then raised, the hemostat marking the external extremity of the tract. If the external ostium is large or gaping, which will only occur

if an infected cyst has been widely incised, a purse-string suture may be used to close it. The flap should consist of skin, subcutaneous tissue, and platysma muscle.

The tract can be injected before the operation with either a colored solution or with bismuth paste. This is, however, rarely necessary, as the tract is not a branching one.

The care of the small internal segment above the level of the digastric muscle has received special attention by many authors. Von Hacker suggests the insertion of a probe into the tract and then fixing the tract to the probe by a ligature. The probe is then pulled through into the oral cavity thus inverting the tract. Koenig suggests the reimplantation of the tract into the pharynx, thus forming a minute oral-pharyngeal fistula. Both of these procedures are almost out of question in the infant. An attempt may be made to follow the Von Hacker procedure using a straight intestinal needle instead of the probe. We have, however, found it sufficient to dissect the tract almost to the pharynx, and then close it with a transfixion suture of fine catgut. The suture is left threaded on a fine, full-curved needle, and this is passed through the pharyngeal submucous tissue. This leaves the patient with a very small pharyngeal diverticulum, which, however, lies entirely in the submucous tissue. Thus, should a diverticulitis ever arise, it can be easily incised in the manner of a peritonsillar abscess and will not spread into the tissues of the neck.

At the closure of the wound, drainage is nearly always necessary. There is often some residual infection, and a dead space, left by the removal of the cystic mass, can rarely be completely obliterated. The drains can be removed in twenty-four hours.

In the postoperative care, the greatest difficulty will be encountered in keeping the infant from soiling the wound with saliva. This is best done by the use of silver foil directly over the wound. This is then covered by dressing material into which some waterproof material, such as oil silk, has been incorporated. To the drains are attached silk sutures so that they may be removed without disturbing the dressing. The wound is then not touched for seven days unless there are special indications.

SUMMARY AND CONCLUSIONS

1. Branchiogenic cysts in infancy constitute a different problem from the therapeutic standpoint than the similar lesions in the adult.
2. The most common complication of branchiogenic cysts is infection. This should be treated as conservatively as possible.
3. In infants under twelve to eighteen months of age, the injection treatment may be used. Precautions have been enumerated.
4. The operative treatment is the therapeutic measure of choice. The manner of the incision and the care of the proximal segment of the tract have been described in detail.

Editorials

The Prevention and Arrest of Hemorrhage Following Gastroenterostomy

IT HAS become recognized quite generally that a continuous, inverting, through-and-through suture of the Connell type has three important disadvantages when used in gastric and intestinal surgery. In the first place, it tends to produce a considerable diaphragm across the stoma, which, although temporary, is undesirable, especially in end-to-end anastomosis of the small intestine. Second, anyone who has used the stitch on laboratory animals and has observed the appearance of the suture line from within the bowel immediately after operating, and also during the various stages of healing up to two weeks, will have noted the ragged and irregular initial ridge, the small areas of ulceration where the mucous membrane is not accurately opposed, and the consequent delay of healing. The appearance and the reparative process, as observed from without, are perfect; from within, both leave much to be desired. Whether or not the slight scarring which results from the small temporary ulcerations is of importance may be questioned, but still, any additional fibrosis seems undesirable and unnecessary.

The third, and most important, objection to the Connell type of suture is that it does not insure adequate hemostasis. This is true particularly in gastroenterostomy, where bowel walls of unequal consistence, thickness, and vascularity are opposed. If the method with clamps is used, there is great danger of postoperative bleeding if a Connell stitch is inserted anteriorly. This danger is decreased if care is taken to ligate, individually, all vessels on the gastric side and the larger vessels on the jejunal side, loosening the clamps to observe for bleeding before the lumen is closed. Still, there is an uncompressed area between adjacent loops of the stitch from which bleeding will occur if a vessel has been missed. Vessels which have not bled at the time of operation may begin to bleed and continue to do so with elevation of the blood pressure after operation.

The subject of the Connell suture was brought to mind by two recent articles on gastroenterostomy^{1, 2} in which no point was made of the disadvantages of the suture under discussion.

My two personal experiences with hemorrhage from gastroenterostomies occurred ten years ago. Since that time I have avoided the Connell suture for the most part and have substituted an over-and-over continuous chromic catgut stitch including all layers. In my two

cases, the gastroenterostomies were for chronic duodenal ulcer. Clamps and a continuous chromic catgut Connell suture anteriorly were used. The larger gastric vessels were divided between mosquito forceps and ligated with fine chromic catgut before the stomach was opened. In each case, after loosening the clamps and just before the Connell suture was placed, two or three of the vessels on the jejunal side were tied. Within the first hour after operation, while recovering from ether, both of these patients vomited enough bright red blood to indicate progressive, dangerous hemorrhage. In both, I reopened the abdomen, made a short linear incision in the anterior wall of the stomach, aspirated the bloody gastric contents, and picked up the two sides of the stoma, from inside the stomach, with Allis forceps. In the first of the two patients, there was a small artery pumping blood from the middle of the Connell suture. A figure-of-eight stitch stopped it. In the second patient, there was a steady ooze from the stoma, mostly from the side of the Connell stitch. This time, a continuous through-and-through fine chromic catgut suture was placed entirely around the opening. Both patients recovered.

Although most surgeons have discarded the continuous inverting suture for gastroenterostomy, not much has been written about its disadvantages, and I have never seen the transgastric approach for the control of hemorrhage described. The complication in its severe form should no longer occur, but the simple and certain transgastric route, obviating, as it does, a shocking and more difficult direct attack on the stoma from the outside, may prove valuable to anyone faced with the necessity of saving such a patient.

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Selective Thoracoplasty

OPERATIONS on the chest wall to produce permanent collapse of the underlying tuberculous lung have been performed for more than twenty-five years. During this time great advances have been made both in regard to the more effective control of the disease and to a lowering of the operative mortality. Particularly interesting and natural has been the development of a more truly selective type of thoracoplasty, paralleling in principle the evolution of the modern operation for trigeminal neuralgia, from extirpation of the gasserian ganglion to subtotal resection of the sensory root.

Some twenty-five years ago when the operation of thoracoplasty was first being used in the treatment of pulmonary tuberculosis, there was discussion by Wilms, Sauerbruch, and Friedrich in regard to the extent to which the costal resection should be carried. For a short period of time it was agreed among these pioneers that the extent of the rib resection could be limited to the area overlying the diseased part of the lung. Soon, however, due to bad results attributed to aspiration by the normal part of the lung of infected secretions from the collapsed part, Sauerbruch urged and practiced complete thoracoplasty in practically all cases. He emphasized the need for collapse of the lower and more normal portions first to prevent this aspiration; and he completed the thoracoplasty in one or two stages. He furthermore believed that complete rest for the entire lung was important even though all parts were not diseased. As he taught and practiced, so also did most of the thoracic surgeons of that period.

For the next fifteen years, the custom of performing a complete posterior thoracoplasty in all cases was quite universally followed. Then a swing back to the earlier idea of limited thoracoplasty became increasingly marked. There were changes in technic allowing a greater local collapse by resection of longer segments of ribs, or by adding extrapleural packing to the rib resection. As more and more cases were thus treated and the results proved to be good, the complete operation came to be reserved for special cases.

Thoracoplasty has quite naturally followed the lead of pneumothorax therapy in its development and has followed a course closely paralleling that of the latter. When artificial pneumothorax was first practiced in the 1880's, a complete collapse of the affected lung was commonly attempted. As it became apparent that the diseased part of the lung could be selectively collapsed and the disease controlled, this method became standard. Furthermore, by this limitation of the collapse to a part of a lung, it became possible to apply this treatment to cases in

which parts of both lungs were involved. This great advance in pneumothorax therapy was followed some years later by the application of the same principle in using bilateral partial thoracoplasty. Today the mere fact that tuberculosis is present in both lungs does not preclude the possibility of collapse therapy.

During the last few years, other modifications of the technic of thoracoplasty have been developed in order that greater local collapse might be obtained without handicapping the good part of the lung. The addition of chondral resection, or hinging, to the complete resection of the upper ribs produces a marked degree of local collapse. The resection of the lower end of the scapula to allow it to fall in over the collapsed lung without extending the rib resection below the fifth or the sixth rib is another step in the direction of preserving normal lung tissue while securing adequate collapse of the diseased part. But of all the modifications that have been described, it seems that the operation perfected by Semb represents the greatest advance. In this procedure, called "thoracoplasty with extrafascial apicolysis," large cavities in the upper part of the lung may be completely collapsed without recourse to extensive anterolateral resections or total thoracoplasties; and in cases with small apical cavities, complete closure frequently follows the first-stage operation.

This operation of Semb's differs from others previously described in that following an extensive resection of the upper ribs, the apex of the lung with its overlying pleura, intercostal structures, and costal periosteum is completely mobilized. This is accomplished in several steps. First, the scalene muscles are divided well above the first rib. Then, the costal periosteum and intercostal structures are cut across near their connections with the vertebral column and with the sternum in the region of the first chondrosternal junction. Finally, the bands of fibrous tissue running up from the endothoracic fascia covering the apex of the lung to the vertebral column and to the fascia about the brachial plexus and subclavian vessels are isolated and divided. Only loose areolar tissue remains to hold up the apex after this, and following its separation, the apex lies free. The upper lobe is thus allowed to collapse in a vertical direction as well as medially. The subsequent extent of the collapse will be determined by the amount of further rib resection. This may be limited to an apical thoracoplasty or may be extended to a complete thoracoplasty. Having once freed the apex of the lung and resected the overlying ribs, the way has been cleared for a true concentric collapse of the underlying pulmonary tissue.

The operative mortality in the reported series has been very low when the extent of the rib resection has been limited to six ribs or less at one stage (3 per cent of seventy-seven patients). In a number of clinics in this country, the mortality rate with the usual form of thora-

coplasty has been no higher than this, and lower in some instances. This point is, therefore, in itself no reason for adopting this technic. However, when one considers the success obtained in cavity closure, it is seen that in a series of 133 patients the cavity was closed in more than 90 per cent; and in another series of eleven patients whose cavities had resisted closure by the usual methods, ten had been closed by the new technic. It is in this important field, the treatment of the elusive cavity, that this operation has been of the greatest value.

Although there have been as yet no reports on the use of this operation in this country, a number of thoracic surgeons here have been performing the operation since its description was published in 1935. Their results have closely paralleled those of Semb, and their endorsement of the principles involved has been enthusiastic. Complications have been few when the careful and painstaking technic of Semb has been followed. However, the operation carries with it considerably more risk than the ordinary form of thoracoplasty, and if not carried out with meticulous attention to sharp dissection and hemostasis, the results may be disastrous. But this need for a more time-consuming and exacting technic is more than compensated for by the results obtained. By this operation we can achieve the closest approach yet made possible to the truly selective collapse of the diseased lung.

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Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

ADVANCES IN ROENTGEN DIAGNOSIS

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(From the Department of Radiology, University of Minnesota)

Part II*

ADVANCES IN DIAGNOSTIC METHODS AND DIAGNOSTIC CRITERIA

THE APPLICATION of new methods of procedure, such as kymography, to roentgen diagnosis represents one of the distinct advances of the past few years. Of particular interest to surgeons is the application of this method to the diagnosis of the surgical diseases of the lungs as reported by Cola and Lo Monaco³⁶ and Torelli.³⁷ The work of Scott and Moore³⁸ and Hirsch³⁹ must also be recorded in this regard, particularly with reference to the demonstration of pericardial lesions such as effusion and adhesions by this method. Likewise the application of planigraphy and tomography to roentgen diagnosis has been detailed to some extent by Chaoul and Greineder,⁴⁰ in the demonstration of lung abscess, and by Andrews.⁴¹

The development of roentgen diagnosis during the past decade has hinged largely about the use of contrast media of various types. While there have been no entirely new innovations in this field since 1932, numerous changes have occurred in the use of the contrast substances which had already been described. The development of encephalography has proceeded apace, due in part to the contributions of Dyke and Davidoff,⁴²⁻⁴⁸ describing improvements in technique and, particularly, placing the interpretation of encephalograms on a sounder basis by their description of the normal appearance of the various structures in the cranial cavity. The excellent reviews of the value of encephalography and ventriculography by Adson⁴⁹ and by Pilcher and Wilson⁵⁰ have added considerably to our knowledge. The criteria for the diagnosis of cysts of the *Septum pellucidum* are well described by Pendergrass and Hodges.⁵¹ Other improvements in the technique of encephalography⁵² and a procedure permitting clear visualization of the third and fourth ventricles have been reported by Dyes.⁵³ The value of encephalography, in children particularly, has been well elucidated by Eley and Vogt.⁵⁴

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Distinct changes in the character of the contrast substances used have been reported particularly by Newman,⁵⁵ who advocates the use of anesthetic gases, such as ethylene. This may be helpful in relieving the untoward symptoms produced by gases which absorb more slowly. Schoenfeld and Freeman,⁵⁶ Freeman, Schoenfeld, and Moore,⁵⁷ and Twining and Rowbotham⁵⁸ have described the combined use of thorium dioxide sol (thorotrast) with air in ventriculography. While there is some doubt as to the safety of this procedure because of the possible immediate and late effects of thorotrast, the possibilities bear further study. There have been, in addition, numerous individual contributions to the interpretation of various abnormalities in the ventriculogram and the encephalogram.

A new development first described by Egas Moniz⁵⁹⁻⁶¹ and since elucidated further by other authors⁶²⁻⁶⁵ envisages the injection of thorotrast into the internal carotid artery to produce a visualization of the blood vessels of the brain. In this way, changes due to tumors or other deformities may be clearly made out. This procedure has not won great favor in this country but appears to be without any great danger. It is somewhat difficult to do from a technical standpoint but may have further application as described by Loman and Myerson.⁶⁶

In the interpretation of intracranial lesions, the work of Kopylov⁶⁷ has added considerably, particularly to our understanding of the effects of hydrocephalus on the bony structure; and he believes that even without the use of contrast substances some evidence may be ascertained as to the localization of the obstruction in hydrocephalus. Great improvement in the understanding of the bony changes which occur from other intracranial lesions has occurred due to the contributions of Pancoast.⁶⁸ The importance of intracranial calcifications has been stressed by Löw-Beer,⁶⁹ and the changes produced by tumors of the acoustic nerve are well described by Ebenius.⁷⁰ The abnormalities produced by pituitary tumors and other tumors at the base of the skull have been elucidated by Mayer.⁷¹ In a recent article Sosman,⁷² presents a general review of the value of the roentgenology of the skull in intracranial lesions, and he gives an excellent picture of the present situation.

The effect of intrinsic lesions of the skull itself upon the roentgen picture is well described in papers on this subject by a number of authors. The recent contributions of Moore^{73, 74} add much to our knowledge of the metabolic craniopathies and of the significance of hyperostosis cranii. Geschickter⁷⁵ has described the changes occurring from primary tumors of the cranial bones themselves, and in a paper by Kasabach and Dyke⁷⁶ some increased clarification of the subject of osteitis circumscripta and its roentgen appearance is afforded. Vance⁷⁷ has described the roentgen appearance of the healing of skull fractures and the period of time which must elapse before evidence of union may be detected in the roentgenogram.

The use of iodized oil in the diagnosis of spinal cord tumors has continued, but with some misgivings, on the part of those utilizing the method. It has been felt that the indiscriminate injection of iodized oil in the spinal canal may produce deleterious changes in the meninges.⁷⁷ Nevertheless, when indicated, it is of great value and should be perhaps used in larger quantities than in the past.

A rather new development in the roentgen diagnosis of spinal canal lesions is that which was preceded by the work of Mixter and Barr,⁷⁹ and others. They demonstrated that a rupture of the intervertebral discs might occur from trauma; from this may result an extrusion of the nucleus pulposus posteriorly and secondary compression of the nerve roots or of the spinal canal. Hampton and Robinson⁸⁰ have demonstrated brilliantly the roentgen findings under these circumstances after the injection of 5 c.c. of lipiodol, roentgenograms being made in the posteroanterior projection, and Love and Camp⁸¹ have since confirmed their observations. A correct diagnosis of this condition can only be made in this manner.

The bony changes which occur in the spinal canal secondary to lesions of the spinal cord, particularly tumors, have been well described by Camp, Adson, and Shugrue.⁸² They find changes in the pedicles which are diagnostic in almost half the cases. A method of examination in which measurements are made between the pedicles of the spine to determine an increase in the size of the spinal canal as a result of tumors is advocated by Elsberg and Dyke⁸³ and no doubt is of considerable value in certain cases provided the normal variation is taken into account. A general review of the value of a roentgen examination of tumors of the spinal canal in childhood is afforded by Hamby.⁸⁴

Increased knowledge of the presence of accessory processes and of congenital anomalies of the spine is presented in the papers of Farmer,⁸⁵ Evans,⁸⁶ and Wagner.⁸⁷ The roentgen manifestations of tuberculous of the spine are well shown in the contribution of Doub and Badgley,⁸⁸ and the findings produced by osteomyelitis and nontuberculous infections have been described by Sussman.⁸⁹ Congenital anomalies involving the lumbosacral joint and those associated with spondylolisthesis are brought out in the papers of Meyerding⁹⁰ and Ferguson.⁹¹ A new review of the subject of juvenile kyphosis by Scheuermann,⁹² who originally described this disease, has appeared, and he has clarified our conception of vertebral osteochondritis by correlating his research with the investigations of Schmorl on the nucleus pulposus as reported by Junghans.⁹³ Compere and Keyes⁹⁴ have also added to our knowledge of the importance of the intervertebral disc and the effects of trauma and other diseases upon the roentgenographic appearance of the spine.

A rather recent development in the use of contrast substances is involved in the work of Lühr and Jacobi,⁹⁵ who injected thorotrast into the nerve sheaths, describing the normal appearance and the changes

which result from injuries and other abnormalities. Saito⁹⁶ has more recently outlined this procedure and indicated particularly the changes occurring from injury and tumor under such circumstances. This appears to be a valuable procedure for the diagnosis of lesions of the peripheral nerves.

Further utilization of contrast substances may be noted in the work on direct arteriography and venography in which contrast substances of various types are injected into the blood vessels. At the present time, the most commonly used contrast substance is thorotrast, although some authors prefer diodrast or neoipax, while frequently sodium iodide itself is used. Numerous contributions in this field have been reported. Valuable information as to the application and technique of this procedure in the study of the arteries is afforded in papers by Pearse and Warren,⁹⁷ Allen and Camp,⁹⁸ and Veal and McPetridge,⁹⁹ while Wohlleben¹⁰⁰ and Barber and Orley¹⁰¹ detail the diagnostic possibilities of injection of the veins.

Although first described in 1929 by Radt,¹⁰² the development of the use of thorium dioxide sol (thorotrast) for the diagnosis of the diseases of the liver and spleen has been rather slow, due largely to the fears which failure of excretion of this slightly radioactive material has engendered. In spite of the rather pessimistic report of Stewart, Binkhorn, and Illick in 1932,¹⁰³ numerous papers have reported encouraging results with the use of this substance.¹⁰⁴⁻¹⁰⁸ The utilization of this method for the determination of metastases in the liver and spleen has been particularly described by Eriksen and Rigler¹⁰⁹ and by Hirsch and Morton.¹¹⁰ The end-results have been studied by Rigler, Koucky, and Abraham,¹¹¹ Naegeli and Lauche,¹¹² Yater, Otell, and Hussey,¹¹³ and others, but the final effect of this material is still somewhat in doubt, and conservatism must be exercised in its use. There is no doubt that accurate diagnoses as to metastases and other diseases of the liver may be made by the intravenous injection of thorotrast, but its use should still be restricted to serious ailments in elderly individuals.

A relatively new roentgenographic procedure of great interest to surgeons is that designated as cholangiography, in which a roentgen opaque substance is injected into the common bile duct either through a needle during the operation, as described by Mirrizi,¹¹⁴ or after operation through a drainage tube which has been put into the common duct. The use of various opaque substances has been advocated, iodized oil being used by Ginzburg and Benjamin,¹¹⁵ diodrast and other iodine compounds by Robins and Hermanson,¹¹⁶ and Iicken, Best, and Hunt.¹¹⁷ Saralegui¹¹⁸ has found greater success with thorotrast. The ability to demonstrate occlusion of the common duct, stones, and other lesions, not only in the common duct itself but in the smaller bile ducts, has been well demonstrated; this procedure is of great value in the demonstration of the condition of the biliary tract following operations on the gallbladder or even during the operative period.

The use of contrast substances in the diagnosis of diseases of the joints, while in no sense new, has received some further impetus through the studies of Bircher,¹¹⁹ who advocates the use of air. Nagy and Polgar¹²⁰ have used uroselectan and other iodine compounds with considerable success, demonstrating lesions of the joints otherwise not clearly visible in the roentgenogram. Keller¹²¹ has reviewed the value of these various media in diagnosing joint diseases. More recently Simon, Hamilton, and Farrington¹²² have advocated the use of air particularly for the diagnosis of injuries of the semilunar cartilages which, in the ordinary roentgenogram, may give little or no findings.

In the diagnosis of lesions of the salivary gland, considerable difficulty has been encountered in the past. For this reason Barsky and Silverman¹²³ and Payne¹²⁴ advise the use of contrast substances, especially lipiodol, injected directly into the salivary ducts. Obstructions due to stones or other lesions, or ruptures of the duct may readily be demonstrated in this fashion.

Improvement in the roentgen diagnosis of diseases of the lungs was greatly enhanced many years ago by the introduction of bronchography, the examination of the bronchi with the use of contrast substances, particularly lipiodol. Changes in the methods of introduction of this material have taken place to some extent and the utilization of this method in the diagnosis of carcinoma of the lung, a vitally important subject in this present day, has been reported particularly by Greenbaum¹²⁵ and Farinas.^{126, 127} The use of this method in the study of postoperative lung diseases and in bronchiectasis has been particularly brought out by Hedblom and van Hazel.¹²⁸

Roentgen studies on the diagnosis of carcinoma of the lung have been very numerous in the past five years. Outstanding among these are the observations of Manges¹²⁹ and Kerley.¹³⁰ Further details in diagnosis have been recently reported by Farrell,¹³¹ especially as to the value of the roentgen observation of atelectasis, increased linear markings of the lungs, and other changes. A further report on the roentgen findings in pulmonary sulcus tumors by Paucoast¹³² and a general description of the appearance of extrapulmonary tumors by Peirce¹³³ must also be considered. A large number of papers have appeared detailing the roentgen findings in cystic disease of the lung, and a general review of this subject by Bloesser¹³⁴ and Kirklin¹³⁵ should be noted. Numerous contributions on the appearance of the lungs after rib resections and other operative procedures are of considerable importance; among others, the paper of Farrell¹³⁶ is illuminating. Improvements in the diagnosis of various specific diseases, such as the specific sign reported by Phemister, Steen, and Volder-aer¹³⁷ for the diagnosis of dermoid cyst and the description of the appearance of infected hydatid cysts by Tillier,¹³⁸ are of some importance. Elucidation of the significance of the basal triangular

shadows frequently observed in children as being due to atelectasis and bronchiectasis has been afforded by the work of Anspach,¹³⁹ Warner and Graham,¹⁴⁰ and Richards.¹⁴¹ Further assistance in the localization of foreign bodies in the lungs is given by the paper of Manges.¹⁴² While the roentgenologic findings in silicosis and silico-tuberculosis are well established, further additions to our knowledge have been made by Pancoast and Pendergrass^{143, 144} and Garland,¹⁴⁵ while the specific findings produced by asbestosis are described by Shull.¹⁴⁶

The roentgenologic manifestations of diseases of the pleura have been described by a number of authors. The anatomic distribution of the interlobar fissures and the explanation of the roentgenologic picture produced by diseases of these reflections of the pleura have been well described by Levitin and Brunn.¹⁴⁷ Evidences as to the mode of development of encapsulated interlobar effusions was reported by Rigler.¹⁴⁸ A general description of the roentgenologic findings in diseases of the pleura can be found in the section on this subject by Liebmann.¹⁴⁹ Newer methods of procedure in the roentgen examination of the thorax, particularly for the demonstration of pleural adhesions, have been described by Haight and Peirce.¹⁵⁰ The use of opaque substances in outlining the mediastinum as to its movements, normal appearance, and the effect of abnormalities upon it have been described by von Pannwitz,¹⁵¹ who injected uroselectan directly into the mediastinal space by needle puncture. This procedure, however, has not been generally adopted.

The importance of the roentgen examination of the urinary tract has assumed greater and greater proportions in the past few years, particularly with the full development of excretion urography. A general description of the uses of intravenous urography is found in the article by one of the original discoverers of the method.¹⁵² Other general descriptions of its application are reported in papers by Braasch,¹⁵³ Kornblum,¹⁵⁴ and Dyes.¹⁵⁵ The utilization of intravenous urography in children is well described in a paper by Campbell.¹⁵⁶ Swick,^{157, 158} the originator of this remarkable improvement in the roentgen diagnosis of urinary diseases, describes the general findings and also adds a new type of opaque substance which may be used by oral administration with a moderate degree of success, although the results are uncertain. The subcutaneous injection of neoskiodan has been advocated by Beer and Theodore,¹⁵⁹ who report some success with its use, particularly in children. Swick,¹⁶⁰ in another paper, outlines the value of the various types of opaque substances which can be used and particularly describes the usefulness of sodium orthohippurate. Other uses of excretion urography have been adequately brought out by Wesson,¹⁶¹ and its particular utility in the diagnosis of traumatic lesions of the urinary tract is described by Coe.¹⁶² The value of both intra-

venous and retrograde pyelography in the diagnosis of tuberculosis of the kidneys and upper urinary tract has also been studied.^{163, 164}

A classification of the tumors of the urinary tract has been made by Nichols,¹⁶⁵ particularly with regard to their manifestations in the roentgenogram. The criteria for diagnosis of papilloma of the kidney pelvis are well described by Jansson.¹⁶⁶ A method of procedure is again elaborated by Sutherland¹⁶⁷ for the roentgenoscopy and roentgenography of the kidney at the operating table in order to eliminate the possibility of stones remaining in the kidney after a surgical procedure.

Further investigation of the use of contrast substances in the lower urinary tract has been made by Migliardi,¹⁶⁸ who describes a method of visualizing the urethra and the bladder by means of descending cystourethrography. The use of double contrast media, barium and air in the urinary bladder, has been advocated by Santoekij,¹⁶⁹ and Gillies and Kerr¹⁷⁰ have described their method of using an opaque medium in the posterior urethra combined with air in the bladder. The injection of the seminal vesicles with lipiodol is again described in some detail by Junghanns.¹⁷¹

In the roentgen study of the gallbladder, the changes in technic outlined above represent the more outstanding contributions. The study of what may be called choledochography by Kommerell¹⁷² brings out the fact that following a fat meal during the contraction phase of the gallbladder the common duct can be clearly visualized filled with the dye, and a study of this may be of considerable value. Anatomic variations in the appearance of the gallbladder have been well described by Gross,¹⁷³ and the roentgen appearance of an anomaly of the fundus, the Phrygian cap gallbladder, has been clearly elucidated by Boyden.¹⁷⁴ The roentgen findings in benign tumors of the gallbladder, particularly papillomas and adenomas, have been described for the first time by Kirklin,¹⁷⁵ who indicated certain specific signs to identify such lesions. The importance of the demonstration of air in the biliary ducts by roentgenographic examination as a sign of internal biliary fistula is emphasized by Powers,¹⁷⁶ and other methods of demonstrating biliary duodenal fistula are again pointed out by Bentel.¹⁷⁷

The roentgen study of the soft tissues of the neck received great impetus from the book on this subject by Hay.¹⁷⁸ Further observations on the roentgen study of the tissues of the neck have been made by Pancoast,¹⁷⁹ particularly with reference to tumors of the pharynx, upper esophagus, and about the larynx. A relatively new study of the esophagus has been made with the purpose of demonstrating varices which, prior to this time, have been considered practically invisible in the ordinary roentgenogram. Changes in technic have enabled excellent demonstration of varicosities as shown in papers by Bentel¹⁸⁰ and others.^{181, 182}

Considerable interest is still exhibited in the diagnosis of changes about the hiatus esophagens, as illustrated by the paper of Schatzki,¹⁸³ who described the increased mobility of the stomach in this region. An extensive description of the anatomy and the roentgenologic findings in hiatus hernia is afforded by Harrington¹⁸⁴ and also by Knothe¹⁸⁵ and Wagner.¹⁸⁶ Recent observations by Manges and Clerf¹⁸⁷ would seem to indicate that many of these paraesophageal hernias previously reported are really due to a congenitally short esophagus, and some confirmation of this theory is afforded by Dunhill.¹⁸⁸ While there are undoubtedly certain cases in which the congenitally short esophagus is the cause of an apparent hernia, the vast majority of cases are no doubt due to increased intraabdominal pressure together with a weakened esophageal hiatus.

There have been no outstanding contributions during this period to the roentgen diagnosis of diseases of the stomach, but there are a number of papers which are of considerable interest. The study of the mucosa of the stomach has continued with greater effort, and a description of the anatomy and physiology of the mucosa by Forssell¹⁸⁹ is of great value in elucidating its roentgen appearance. Dahm and Mayer¹⁹⁰ have also pointed out the correlation between the anatomy and the roentgen findings. The series of articles by Cole and others¹⁹¹⁻¹⁹³ detailed their observations on the anatomy and pathology of the gastric mucosa and their relationship to the roentgenographic picture. Further additions to our knowledge of the physiology of the stomach and the effects of various procedures on its emptying have been afforded by the papers of Pendergrass, Ravdin, Johnston, and Hodes.^{21, 194} The roentgen appearance of the operated stomach after various surgical procedures is well described by Niedermayr¹⁹⁵ and Held.¹⁹⁶ The question of the malignancy or benignity of ulcers in the prepyloric region has been dealt with in considerable detail by Holmes,¹⁹⁷ who believes that practically all ulcers in antrum will eventually prove to be malignant; while Singleton¹⁹⁸ has described a number of cases in which definite ulcers in the prepyloric area have proved to be benign. While it is no doubt true that a preponderance of these lesions are malignant, no definite statement can be made purely on a basis of location. The frequency of benign tumors of the stomach and their malignant degeneration, together with the roentgen characteristics of such lesions, are described by Rigler and Eriksen.¹⁹⁹ The importance of the prolapsing lesions of the mucosa of the stomach again was brought out in the paper of Pendergrass and Andrews.²⁰⁰

A lesion of the pyloric end of the stomach commonly mistaken for carcinoma, which had not been recognized to any great extent, roentgenologically, prior to 1932, was well described by Bernstein²⁰¹ and again by Kirklin and Harris.²⁰² This is a hypertrophic stenosis of the

pylorus in adults which may be difficult to distinguish from a tumor but has certain clear-cut roentgenologic characteristics to indicate its benign character.

Sarcoma of the stomach is not a rare condition, and the roentgenologic characteristics have been well described by Kessler²⁰³ and also by Spitzenberger.²⁰⁴ The appearance which lymphomata of various types produce in the stomach and other portions of the gastrointestinal tract is well detailed by Holmes;²⁰⁵ and more recently Martin²⁰⁶ has described the roentgen appearance of lymphogranulomata of the stomach itself.

Much attention has been directed to the small intestines in recent years because of the realization that various diseases, particularly tumors, are amenable to roentgen examination if the technic is properly carried out. Accordingly, a paper by Pansdorf²⁰⁷ detailing the technic of study of the small intestine and its normal appearance is of considerable importance. The findings produced by idiopathic steatorrhea in the small intestine, the colon, as well as in the bones, were well described by Bennett, Hunter, and Vaughan in 1932.²⁰⁸ Snell and Camp²⁰⁹ have also detailed the roentgenologic and clinical findings in this condition, often called nontropical sprue. Typical dilations, irregularities, and peculiar distributions of the small intestinal loops may be found. The effect of inflammatory lesions in interfering with the motor phenomena of the intestines and their roentgenologic appearance is well described by Cole and Pound.²¹⁰ The roentgenologic findings in ileus, particularly with regard to the importance of the demonstration of gas in the small bowel, are emphasized by Ochsner,²¹¹ while the importance of the demonstration of fluid levels in the diagnosis of intestinal obstruction is brought out by Durst and Utzschneider.²¹² The danger of giving barium in ileus is well recognized and is emphasized in a paper by Prevot.²¹³ While most diverticula of the intestinal tract have been readily accessible to roentgen examination, it has been notably difficult in the past to diagnose a Meckel's diverticulum roentgenologically. This, however, has been successfully done, as reported by Pfahler in 1934²¹⁴ and Prevot in 1936.²¹⁵

The roentgen diagnosis of tumors of the duodenum has been well described by Hrabosky²¹⁶ and a report of a series of cases of carcinoma of the small intestine, with the roentgenologic manifestations, was made by Doub and Jones in 1936.²¹⁷ Careful attention to technic will permit the diagnosis of small intestinal tumors in a high percentage of cases.

A description of a new disease syndrome, regional ileitis, by Crohn, Ginzburg, and Oppenheimer²¹⁸ has led to the determination of the roentgenologic findings which are the most important means of diagnosis in this unusual condition. Kantor²¹⁹ has described very well

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ondary phenomenon, nevertheless, his demonstration of the x-ray changes is of considerable value. Camp²³⁶ in 1932 reported ten cases with characteristic roentgenologic findings and elucidated very well the characteristic roentgen features. In a later paper, Elmslie, and others²³⁷ reported a very large number of cases of various types with characteristic findings. The importance of the roentgen demonstration of calculi in the kidney in these cases was emphasized by Lahey and Haggart,²³⁸ and in a paper by Moore and de Lorimier²³⁹ there is a general review of the roentgen appearance of the deossification which occurs from disease of the parathyroid gland. A recent review by Camp²⁴⁰ of the various malacic diseases is very illuminating in this regard and helps to classify the roentgenologic findings which are characteristic of the various conditions producing osteoporosis.

A suggestion for the use of thorotrast in the early diagnosis of osteomyelitis was made by Sedgenidse and Solotuchin.²⁴¹ They believe that it is possible to demonstrate very small traumatic or infectious lesions of the bone because of the tendency for the reticuloendothelial cells to migrate to a point of disease. Injections, intravenously, of very small quantities of thorotrast revealed, within a short period of time, a collection of this material in the region of a bone lesion. While this work has not yet been confirmed, it presents an interesting possibility for the early diagnosis of osteomyelitis.

Further observations of the diseases which are classified as osteochondritis have been made by Brailsford.²⁴² The malacia of the semilunar bone, originally described by Kienböck, has been again well reviewed by Gillies.²⁴³ Tumors of the bone have received relatively little attention during this period of time. The roentgen appearance as compared with the pathology in lymphoblastomata of the bones is described by Craver and Copeland,²⁴⁴ and the simulation which Hodgkin's disease of bones may make to other malignancies was brought out in a more recent paper.²⁴⁵ The roentgen findings in primary bone tumors of children, which present specific findings, are described by Goin and Carroll.²⁴⁶

Ghormley²⁴⁷ has reviewed well the comparison of the anatomic findings and the roentgenologic findings in a large group of joint diseases, particularly with regard to tuberculosis. He points out the difficulty of diagnosing tuberculosis in the roentgenogram in view of the similar gross pathologic appearance which it may have to other types of joint disease. A large series of cases of bone and joint tuberculosis are reported by Birkelo and Jargynka,²⁴⁸ and the roentgenologic findings are again described. Odessky²⁴⁹ has brought out clearly the anatomic basis for the x-ray findings in so-called posttraumatic periarticular ossification of the knee joint (Köhler-Pellegrini-Stieda's disease). This has been of considerable interest in recent years, and Odessky shows well the exact location of these shadows which are so striking.

the essential features of the roentgenologic examination of ileitis, and recently Sproull²²⁰ has reviewed the subject again and indicated the important findings.

Aside from the important changes in technique which were mentioned in Part I, the diagnosis of lesions of the colon has not been radically altered. A general review of roentgenologic features of carcinoma of the colon by Weber²²³ in 1933 and a paper on the appearance of the colon in the roentgenogram following infestation with ameba by Bell²²² are outstanding contributions. Schwartz²²¹ has reviewed the entire subject of the present status of the x-ray diagnosis of diseases of the colon in comprehensive fashion in the past year. The characteristic roentgen findings in lymphogranuloma inguinale, a stricture of the rectum, were described by Bloom in 1934.²²⁴

The roentgen diagnosis of diseases of the pancreas has never been of great moment, but a recent paper by Haring²²⁵ on this subject adds considerably to our understanding of the changes in the gastrointestinal tract and in the abdomen produced by pancreatic disease. The importance of roentgen examination in the diagnosis of the more acute conditions of the abdomen is well brought out in a contribution by Stewart and Illick,²²⁶ and the demonstration of gas in the peritoneal cavity following the rupture of a hollow viscus is clearly delineated by Finsterhuseh and Gross.²²⁷

Further observations on the roentgen diagnosis of intussusception have been added by Hinstorff²²⁸ and by Ladd and Gross.²²⁹ It is only possible to diagnose ileocecal or ileocolic intussusception by the barium enema method.

In recent years, great attention has been centered on the clinical syndrome produced by infection of the petrous portion of the temporal bone, associated with mastoiditis, and the value of the roentgen examination of this condition has been well pointed out by Kopetzky and Almour.²³⁰ Geyman and Clark in 1932²³¹ demonstrated some of the roentgenologic findings, and more recently Taylor²³² has elucidated the position in which films should be made to demonstrate the petrous apices and the characteristic changes which will occur when infection of this portion of the skull takes place.

While the diseases of the bones associated with hyperplasia and tumors of the parathyroid gland were first described in 1926, the roentgenologic studies of these cases have been of more recent origin. Numerous papers have appeared showing the relationship of osteitis fibrosa cystica to disease of the parathyroid gland and indicating the characteristic roentgenologic findings, which one may see under these conditions. Among these contributions is the paper of Hunter and Turnbull²³³ describing cases of this type with roentgen studies. While the studies of Ballin^{234, 235} may be criticized because of the possibility that many of his patients had hyperplasia of the parathyroid gland as a sec-

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A review of the value of roentgenology in gynecologic diseases, particularly with regard to hysterosalpingography, is offered by Jareho.²⁵⁰ A new procedure for the roentgen diagnosis of placenta previa was first described by Ude and Urner.²⁵¹ This method consists of injecting a small amount of opaque substance into the bladder and making roentgenograms of the pelvis. A marked separation between the head of the fetus and the superior surface of the bladder is evidence in favor of a placenta previa. With certain reservations, this method is highly successful in helping to make a diagnosis of this serious condition.

The clinical findings in lead poisoning, not an uncommon incident of childhood, are described fully by Caffey,²⁵² together with the roentgenologic manifestations. The roentgen findings are also delineated by Vogt.²⁵³ As pointed out in Part I, newer technical measures have permitted the study of the soft tissues to a much greater degree with the roentgen rays, and a summary of many of the findings which can be obtained in this way is afforded in a paper by Carty.²⁵⁴ Gratz²⁵⁵ suggests another procedure, that is, the injection of air into the fascial spaces for the purpose of demonstrating lesions of the muscles and soft tissues. This has been used to some extent, but its possibilities are still very doubtful. The roentgenologic diagnosis of gas in the soft tissues, particularly that occurring with gas bacillus infection, is again described by Rhinehart,²⁵⁶ and he emphasizes the importance of the roentgen examination in the diagnosis of this condition. Further details as to the roentgen diagnosis of lesions of the breast are furnished by Lockwood.²⁵⁷

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Review of Recent Meetings

THE FIFTY-THIRD ANNUAL SESSION OF THE AMERICAN ASSOCIATION OF ANATOMISTS, TORONTO, CANADA, MARCH 25 TO 27

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THE American Association of Anatomists held its annual three-day session this year (March 25 to 27) under the aegis of the University of Toronto. In addition to all-day sessions, a smoker was given on the first evening and a subscription dinner on the second. On the latter occasion the guests assembled to the strains of Scottish bagpipes and were welcomed by the Governor-General of Canada, the Chancellor of the University, and the distinguished Professor Emeritus of Anatomy, Dr. James Playfair Mc Murrich. The association then listened to the scholarly address of its president, Professor Frederic T. Lewis, of the Harvard Medical School, on the subject, *The Fundamentals of Cell Shape*.

As usual the sessions were well attended, some three hundred anatomists, out of a membership of about six hundred and fifty, being present. Altogether, sixty demonstrations (including numerous moving pictures) and one hundred and fifty-one papers were presented in the space of three days. Abstracts of these presentations may be found in the March issue of *The Anatomical Record* (67: No. 4, suppl. 3).

A feature of this, as of the preceding session, was the holding of round-table discussions during the mornings of the second and third days. These covered the following subjects (the chairmen are indicated in parentheses): (1) *Factors in Sperm Production* (Professor Philip E. Smith, Columbia, University); (2) *The Embryonic Heart* (Professor Bradley M. Patten, University of Michigan); (3) *Structure of the Teeth* (Professor T. Wingate Todd, Western Reserve University); (4) *Present-Day Trends of Investigation in the Field of Gross Anatomy* (Professor Robert J. Terry, Washington University); (5) *The Structure of the Neuron and Its Functional Significance* (Professor David M. Bloch, Harvard University); and (6) *Blood Capillaries* (Professor E. V. Cowdry, Washington University). A summary of these discussions will be published in the April or May issue of *The Anatomical Record*.

The hundred and fifty twelve-minute articles were divided among the following fields, approximately as follows: endocrinology (40), neurology (30), embryology (30), histology (30), and gross anatomy (20). Some idea of the congestion resulting from so many presentations may be gained from the schedule of the second morning when six programs (three of a dozen twelve-minute papers each, and three of round-table discussions) were being carried on simultaneously. It is, therefore, impossible for any one person to summarize all the important papers. Accordingly, the following reviews are presented merely as samples of the programs presented at this meeting.

From a surgical standpoint the moving picture demonstration of the successful transplantation of legs from one rat to another, by Justin V. Schwind, of the

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Chicago Loyola University School of Medicine, was perhaps the most striking. The operation consisted of inserting a leg of the donor into a V-shaped incision in a leg of the host, following which the two animals were bound together until the transplanted leg was vascularized. At the time of operation half of the sciatic nerve of the host was sutured to the sciatic nerve of the transplanted leg. Subsequently, pinching of the host's leg resulted in reflex movements of the transplanted limb. Eventually the rat was able to comb its whiskers with the new leg.

Somewhat in contradiction to this experiment was the biologic incompatibility encountered by Higgins and Ingle, of the Mayo Foundation, in transplanting adrenal glands from one rat to another. This incompatibility was lessened when eight or ten adrenals of newborn rats were transplanted to the groin of bilaterally adrenalectomized unrelated adult rats. In nine out of twenty-one cases, there was a functional take; also, it was shown that the culturing of transplants in the tissue fluids of the host did not increase the number of takes.

Another interesting series of observations dealt with the initiation of respiration in fetal stages. William F. Windle, of Northwestern University, reported that respiratory movements in chick embryos begin three days before hatching; that experimental increase in the amount of CO₂ initiates and then deepens respiration; that toward the end of incubation the rhythmic respiratory movements become correlated with pecking movements of the head; and that, after severing the cord from the brain, all but head movements are abolished; thereby suggesting that in the intact animals the gas acts upon the respiratory center of the medulla. Similarly, Snyder and Rosenfeld, of Johns Hopkins University, demonstrated that in rabbits respiratory movements begin as early as ten days before parturition. When India ink was injected into the amniotic cavity, the lungs soon became black, from which experiment the authors concluded that fetal respiratory movements provide a mechanism for preliminary distention of the alveoli with fluid, in preparation for their subsequently more radical distention by air. Apropos to the alveoli, C. C. Macklin, of the University of Western Ontario, presented additional evidence in support of the view that the air spaces of the lung are not bounded by epithelium but constitute a "functional interstitial emphysema."

A third set of observations dealt with the initiation of movements in the embryonic heart. Charles M. Goss, of Columbia University, watched such movements in minute ten-day rat embryos that had been transferred from the uterus to hanging drop cultures. He verified in the mammalian embryo the findings of Patten for the chick, observing that contraction of the embryonic heart begins in the parts formed first—namely, in the ventricle, then in the atrium, and then in the sinus venosus, following which there is a reversal of beat which establishes the normal order of peristalsis. Hof, Kramer, and Patten, of the University of Michigan, recorded the electrical potentials of the embryonic heart and obtained a series of electrocardiograms ranging from the stage of first twitchings in the ventricle to the stage when the cardiogram resembled that of the adult. Both articles were illustrated by microcinematographs of the embryonic heart. Philip B. Armstrong, of Cornell University, employed embryonic hearts prior and subsequent to their innervation to demonstrate that neurohumors, such as acetyl-choline, inhibit the heart by acting upon postganglionic nerves rather than by acting directly on muscle fibers. In studying capillaries Zweifach and Chambers, of New York University, were able to show by the use of mechanically controlled microneedles that individual endothelial cells could be made to contract by localized prodding.

A fourth series of observations dealt with male hormones—thus marking a definite shift of interest away from female hormones, these having received the brunt of attack at the preceding meeting of the association. Roy Greep, of Harvard Univer-

sity, showed that in a large group of animals the follicle-stimulating and luteinizing hormones of the anterior lobe control the development and functional activity of the testis as well as the ovary, the former hormones causing growth of the seminiferous tubules; the latter, growth of the interstitial tissue. As a corollary to this, **Warren O. Nelson**, of Wayne University, demonstrated that in rats administration of extracts of the male hormone will, for at least sixty days, prevent the degenerative changes which occur in the seminiferous tubules after hypophysectomy.

Other reports of unusual interest would include, among others, the following: **C. M. Jackson**, of the University of Minnesota, presented undisputable proof that severe and prolonged underfeeding during early life may prevent full completion of growth later and thus cause permanent dwarfing. **Isaac Schour**, of the University of Illinois, demonstrated that human teeth have growth rings analogous to those of trees, which reflect the physiologic readjustments incident to birth and other vicissitudes of ontogeny. **Allen, Smith, and Gardner**, of Yale University, employed colchicine to arrest dividing cells in the metaphase and thus, by revealing the number of mitotic figures at a given moment, to demonstrate that injections of theelin cause marked increase in the cell divisions of the genital epithelium, uterine muscles, etc., and that injection of the follicle-stimulating hormone of the hypophysis causes rapid growth in the theca of follicles as well as in the granulosa. **Gordon, Kleinberg, and Charipper**, of New York University, showed that the spleen contains an anti-gonadotropic principle which prevents the ovaries of rats from responding beyond certain dosages to hormones of the anterior lobe of the hypophysis—an effect which is abolished by splenectomy. **William Bloom**, of the University of Chicago, showed that lymphocytes of the thoracic duct of rabbits previously sensitized to extracts of *Ascaris* extract developed into pseudoeosinophiles when cultured in *Ascaris* extract. **Sarah Tower**, of Johns Hopkins University, was able to keep puppies alive from two to six months after the lumbosacral cord had been transected above and below and all other incoming pathways severed, thereby demonstrating that functionally isolated nervous tissue is capable of surviving, that it retains its capacity for activity but is not autochthonously active. As a consequence of this, trophic regulation of the nonnervous tissues supplied by this segment of the cord is markedly impaired.

The concluding session consisted of four longer discourses presented at the invitation of the president of the association. The first, by the author, discussed the contribution of the Babylonian Talmud to the anatomy of the lung and to the various kinds of marrows found in the body; the second, by **Professor C. U. Ariens Kappers**, of the University of Amsterdam, described the evolution of the vertebrate hypothalamus; the third, by **Professor S. W. Ranson**, of Northwestern University, discussed the relation of diabetes, somnolence, and temperature regulation to lesions of the hypothalamus; the fourth, by **Professor Bensley**, of the University of Chicago, described the distribution of lipids in protoplasm and their relation to its constitution.

The next annual meeting will commemorate the fiftieth anniversary of the founding of the association in Washington, D. C., 1888.

Book Reviews

The Lung. By William Snow Miller. Cloth. Pp. 212, with 152 illustrations, 20 in color. Springfield, Ill., and Baltimore, Md., 1937, Charles C. Thomas, Publisher. \$7.50.

This interesting monograph on the morphology of the lung, by the professor emeritus of anatomy at the University of Wisconsin, represents a lifelong study of this subject by one who has been referred to as the "dean of American pneumonologists." Beginning with 1892, when he was Mall's first laboratory assistant at Clark University, Dr. Miller has witnessed the emergence of American anatomy from a dissector's art to one of the main productive fields of an age of science. He himself was one of the first in this country to organize effective laboratory courses in histology and embryology.

Curiously enough, his first research problem was the one which was to become the nucleus of this book—the successful attempt to explain the "spheroidal bodies of Roosevelt," to which he subsequently gave the name "atria." That the existence of these obscure subdivisions of the alveolar ducts has not been recognized by many histologists is no reflection upon the high degree of technical proficiency that has always characterized his work.

The first chapter, on the gross anatomy of the lungs, is perhaps the least interesting, probably because it stands unrelated to the modern point of view—that which correlates anatomy with functions and disease.

The second, descriptive of the trachea and bronchi, becomes authoritative by virtue of the author's interesting reconstructions of carinal cartilages and the trachealis muscle. The chapter on intrapulmonary bronchi and bronchioli contains the author's illuminating reconstructions of bronchial muscle.

The fourth, a long chapter dealing with the finer patterns of the air spaces, displays the author's original models demonstrating the existence of atria. One looks in vain, however, for a critical discussion of one of the most significant controversies of the decade—the nature of the pulmonic alveolar epithelium—(see Macklin's report in the *Journal of Thoracic Surgery*, October, 1936). Nor does the long bibliography at the end of the book contain references to important contributions by those who differ from the author in their interpretation of existing structures. I refer to articles on this subject by Bloom (1930), Loosli (1935), and others; and the omission of Macklin's important paper on the musculature of the lung in the *Physiological Review* (1929).

The fifth chapter covers in excellent detail the ramifications of the pulmonary blood vessels. The sixth and seventh do the same for the lymphatics and lymphoid tissue of the lung. Much of these chapters is based on original observations. Chapter eight discusses the nerve supply, an account drawn primarily from the work of the author's student, Professor Larsell, of the University of Oregon. The ninth chapter describes the pleura and is followed by a unique discussion of the architecture of the lung in terms of key points.

The last section is devoted to historic sketches of a rather amazing list of contributors: Malpighi, Willis, Reisseisen, Home, Lereboullet, Bazin, Bourguery, Giralde, Addison, Rainey, Rossignol, Moleschott, Mandl, Adriani, Schultz, Kölliker, Todd and Bowman, Williams, Waters, Gerlach, Schulze, Turner, Rindfleisch, Charcot, Sieda, Laguesse, Berdal, Nicolas, Loescheke and Braus. These are objective accounts reflecting the author's lifelong interest in the history of medicine. One would

wish, however, that he had prefaced these accounts with the ancient views of the lung as an organ for the absorption of fluids or that he had strung these anatomic bits together with something of the sweep that characterizes Sir Michael Foster's history of respiration.

It is obvious, however, that Professor Miller's book is a notable contribution to the subject, not merely for that conciseness of style which permits the assembly of much detailed information, but also because of the excellence of its original illustrations and that vein of authority which comes only from one who has had long and intimate contact with a refractory subject.

Post Graduate Surgery, Vol. II. By Rodney Maingot. Two volumes. Cloth. Pp. 1,825, with 1,134 illustrations. New York, 1936, D. Appleton-Century Company, Inc. \$15 each.

This large tome of 1,825 pages embraces the discussions of eighteen authors upon miscellaneous subjects. Excellent sections on gynecology, urology, and orthopedics appear in it. The other sectional headings relate to the head, spinal column, and salivary glands; the neck; the breast; the thorax; the sympathetic nervous system; the adrenal gland; the injection treatment of hernia, hemorrhoids, hydrocele, and varicocele and varicose veins; and a chapter on infections of the hand. This unorthodox scheme of arrangement of materials followed, it may reasonably be inferred, was not premeditated by the editor.

In the main, the treatment of all the subject matter is very satisfactory. Particularly deserving of commendation is the chapter on the sympathetic nervous system by A. Lawrence Abel. The chapter on the thorax is ably presented by Ro Sleigh Johnson (medical aspects) and T. Holmes Sellers (surgical aspects). Sidney Forsdike writes very interestingly on the subject of sterility in women, incidentally coining many apt phrases.

American readers will find that the writer on pelvic inflammation has not stressed enough the great virtue of conservatism and heat. The Elliot treatment, so widely employed here, receives but indirect, bare mention as pelvic diathermy. Transurethral prostatic resection is described, but one gains the impression that the method has not become so widely adopted in England as here. The only operation described for incomplete testicular descent is transseptal implantation (Manchère operation) in the opposite half of the scrotum.

The section on the injection treatment of hernia contains some very interesting historic material. In defense of the method, which the author endorses, he quotes an admonition from William Penn who said, "neither despise, nor oppose, what thou dost not understand"—a warning which we will still do well to heed. The chapter on orthopedics will be found useful and practical to practitioners. One is somewhat disturbed to find, however, no mention of the value of hyperthermia in the treatment of gonorrheal arthritis. It also seems a little unusual to us in a country where neurosurgery has become a well-recognized surgical specialty to see surgery of the peripheral nerves presented by an orthopedist.

This volume contains a wide variety of material—all authoritatively and well presented. The chief defects in the volume relate to the arrangement of the subject matter and the lack of footnotes or references which should uniformly accompany a reference work of this character. Lucid illustrations and a carefully prepared index greatly enhance the value of the book. Bookmakers would do well to inquire how and under what circumstances the greater number of physicians do their reading. This bulky volume is obviously not meant for a bedside library or the easy chair. The eminently practical treatment of the subject matter should make it a useful addition to the practitioner's library.

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THE TREATMENT OF INTUSSUSCEPTION

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(From the Royal Alexandra Hospital for Children)

THE purpose of this paper is to bring forward evidence in favor of the treatment of intussusception by a preliminary injection per rectum, before resorting to operation; since by so doing, one will find that about 60 per cent of all cases will be completely reduced, and by carefully observing certain signs, one can be quite certain of the completeness of the reduction in 40 per cent of all cases coming under treatment. Of the cases which will require open operation, either because of the uncertainty of complete reduction or because of the certainty of nonreduction, at least 18 per cent will be found reduced at operation. Moreover, one will find that in many of the cases operated upon, because of the doubtful result of the injection, a large number will be found at operation to be almost completely reduced, so much so that it is quite obvious a more prolonged attempt at reduction by injection would have proved successful.

The only rational method of reducing an intussusception would appear to be by applying pressure on the apex of the intussusception from within the bowel; even when operating on these cases, it is this method which is actually employed, although it is done manually through the bowel wall, instead of by water pressure from within the bowel. The only reasonable objection to the employment of the latter method is the difficulty in the diagnosis of complete reduction. The danger of rupturing the bowel can be disregarded, if precautions are taken to use a definite pressure, well below that likely to cause damage to the bowel wall; I have found that the pressure of a column of water,

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three feet six inches in height, which is equal to a column of mercury of sixty-five millimeters, is quite safe. Many years ago I had one case where the intussusception had been present for three days, and where a ring of ulceration was present in the ileum at the apex of the intussusception and a pinhole perforation occurred after using hydrostatic pressure. In this case, although a column of water of the height recommended had been used, the water was held in the bowel, while the abdomen was being palpated to determine the extent of the reduction; so actually a very much greater pressure than that recommended was used. Hence I regard palpation of the abdomen during the actual attempt at reduction by hydrostatic pressure as a dangerous procedure.

From a perusal of the literature on the subject of intussusception, it is obvious that most surgeons unhesitatingly condemn any other method of reduction except open operation; and the statements made show that in most cases, the writers have neither made themselves familiar with the very simple technic nor have they realized that there are certain signs by which one can be quite certain that reduction has been effected. The argument most frequently used in favor of open operation in every case is that by so doing one can be certain that reduction has been effected; and another is that in these days, surgery has reached such a state of perfection that an open operation is quite safe and free from risk.

Now any open abdominal operation on a young infant is attended by a certain mortality, even though it may be a low one; and it is quite obvious that any operation involving extensive handling of the bowel, especially in a young infant already greatly shocked by the telescoping of the bowel and poisoned by the resultant toxemia, will be attended by a very considerable mortality; moreover, an open operation is generally followed by intraabdominal adhesions. It has been my experience when operating for a recurrent intussusception that adhesions are almost invariably present as a result of the first operation. The closure of a midline incision in a very young infant without the risk of some adhesions to the peritoneal scar is a very difficult matter. Adhesions following an abdominal operation in an infant, particularly if the small bowel has become adherent to the abdominal wall, are far more serious than similar adhesions in an adult, because of the probable unequal growth of the segments of the bowel on the proximal and distal sides of the adherent loop, thereby increasing the chances of kinking and obstruction. I have seen several cases of acute intestinal obstruction in children of from six to ten years of age due to kinking of the bowel as a result of adhesions following an operation for intussusception in infancy. A brief history of such a case is as follows:

CASE REPORT.—Female, aged ten years, was admitted to the Children's Hospital as a case of appendicitis, and the appendix was removed. The pain and vomiting

became more acute after the operation, signs of intestinal obstruction developed, and the child died. At postmortem the obstruction was found to be due to the adherence of a loop of small bowel to an old scar in the midline, through which an operation had been done in infancy for the reduction of an intussusception.

I can recall another case of a child developing intestinal obstruction when six years of age, and where an operation for intussusception had been performed by the late Sir Charles Clubbe when the child was six months old. In this case, through-and-through silkworm-gut sutures had been used to unite the abdominal wound in a single layer as was the custom at one time, and since such suturing leaves a ladder of silkworm gut on the peritoneal surface of the incision, adhesions frequently of a dangerous nature must necessarily result.

Apart from these remote risks there is always the danger of obstruction or peritonitis being an immediate result of an open operation. One of the deaths in my own series was due to general peritonitis following an open operation; in this case, the intussusception had been reduced by a preliminary injection. Another case illustrating the danger of open operation was one in which I had successfully reduced an intussusception of over eighteen hours' duration in a young infant. The intussusception recurred six months later, and although early identification of the nature of the trouble was made by the mother who recognized the symptoms as being similar to those present in the first instance, the child being brought under treatment within three hours of the onset and operated upon immediately by a surgeon who had successfully operated on numerous cases of this kind, the child died of general peritonitis seven days later.

These are not isolated cases and are mentioned merely to emphasize the fact that operations on young infants are not free from some risk; even though they may recover from the operation, there is still a risk of trouble developing later on, owing to the presence of adhesions within the abdominal cavity.

Of course, it is not possible to avoid operation in every case, but where such interference can be avoided, both the immediate and late mortality rates, and the morbidity rate will be lowered.

As to the question of the reliability of the method of reduction by hydrostatic pressure, I might mention that after using this method as a routine for over twenty years, in no single instance has a mistake been made in sending a patient back to bed from the operating theater incompletely reduced, where a diagnosis of complete reduction has been made.

TECHNIC OF METHOD OF HYDROSTATIC PRESSURE

Normal saline solution is used for the injection. The quantity varies with the age of the child, but it is the pressure used, not the quantity of solution, which is the important factor. The pressure of a column

three feet six inches in height, which is equal to a column of mercury of sixty-five millimeters, is quite safe. Many years ago I had one case where the intussusception had been present for three days, and where a ring of ulceration was present in the ileum at the apex of the intussusception and a pinhole perforation occurred after using hydrostatic pressure. In this case, although a column of water of the height recommended had been used, the water was held in the bowel, while the abdomen was being palpated to determine the extent of the reduction; so actually a very much greater pressure than that recommended was used. Hence I regard palpation of the abdomen during the actual attempt at reduction by hydrostatic pressure as a dangerous procedure.

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Now any open abdominal operation on a young infant is attended by a certain mortality, even though it may be a low one; and it is quite obvious that any operation involving extensive handling of the bowel, especially in a young infant already greatly shocked by the telescoping of the bowel and poisoned by the resultant toxemia, will be attended by a very considerable mortality; moreover, an open operation is generally followed by intraabdominal adhesions. It has been my experience when operating for a recurrent intussusception that adhesions are almost invariably present as a result of the first operation. The closure of a midline incision in a very young infant without the risk of some adhesions to the peritoneal scar is a very difficult matter. Adhesions following an abdominal operation in an infant, particularly if the small bowel has become adherent to the abdominal wall, are far more serious than similar adhesions in an adult, because of the probable unequal growth of the segments of the bowel on the proximal and distal sides of the adherent loop, thereby increasing the chances of kinking and obstruction. I have seen several cases of acute intestinal obstruction in children of from six to ten years of age due to kinking of the bowel as a result of adhesions following an operation for intussusception in infancy. A brief history of such a case is as follows:

CASE REPORT.—Female, aged ten years, was admitted to the Children's Hospital as a case of appendicitis, and the appendix was removed. The pain and vomiting

solution; on such occasions an x-ray film has been taken to demonstrate the presence of the opaque fluid in the small bowel (Fig. 2).

SIGNS OF COMPLETE REDUCTION

1. *Abdominal distention.*—There are several signs indicating probable reduction, but the only trustworthy sign indicating complete reduction is abdominal distention after the injection which remains



Fig. 2.—An x-ray after thin barium injection retained under pressure for ten minutes. Note opaque solution in coils of small bowel.

after the saline solution has been allowed to escape from the large bowel. The distention is quite obvious on inspection and feels firm on palpation. One is obviously palpating an abdomen where a large portion of the small bowel is distended by fluid.

In most cases of intussusception of under twenty-four hours' duration, the abdomen is soft and flaccid when first seen, although in long-standing cases the abdominal distention of intestinal obstruction is present; in such cases, an operation should always follow the injection

of saline solution three feet six inches high is used. I believe the bowel is liable to rupture from a pressure of five feet, so that there is a good margin of safety. A general anesthetic is administered, and the treatment is carried out in a room adjoining the operating theater and is not done on the operating table. Both patient and surgeon are prepared as for an open operation; so that beyond changing gloves, no time is lost if an operation proves to be necessary. An ordinary douche may be used, but a glass container where the level of the water can be seen is better. The vessel is suspended so that the height of the column of saline solution is three feet six inches above the table on which the child is lying. A No. 15 soft rubber catheter is inserted a few inches into the rectum, and the buttocks are pinched together



Fig. 1.—Illustrates the method of retaining catheter in rectum during injection under pressure.

around it so as to prevent any saline solution from escaping (Fig. 1). No lubricant is used, as otherwise it is difficult to hold the catheter in the bowel. As the saline solution slowly runs in, one can follow the outline of the distended colon. After about three minutes the catheter is disconnected and the saline solution allowed to escape into a bed pan. The return of this first injection generally clears out most of the blood and mucus and possibly some feces from below the obstruction. The process is repeated twice, giving about three minutes on each occasion. Occasionally I have used a single injection, holding it in the bowel for from eight to ten minutes. After the injection, as much of the saline solution as will come away is allowed to escape, so that the large bowel is left practically empty after the treatment. On several occasions I have used a thin barium solution instead of saline

5. *X-Ray Film After Opaque Injection.*—When thin barium solution has been used instead of saline solution, the presence of some of this in the small bowel, as seen by x-ray examination, would indicate complete reduction.

6. *Use of Charcoal to Verify Reduction.*—On a number of occasions I have left about one teaspoonful of powdered charcoal in the stomach by suspending it in about one-half ounce of water and passing a stomach tube. In cases of complete reduction, some of the charcoal, which is very easy to identify, can be recovered within five hours by washing out the large bowel. Although I do not regard this sign as one to be used to decide the question of open operation, still where the intussusception is of only a few hours' duration and where reduction by injection has been attempted, one can obtain by this means absolute confirmatory evidence of complete reduction, even in the absence of abdominal distention and even in cases where there is other positive evidence of complete reduction; the giving of charcoal in this way gives an added feeling of security, because if one could not recover

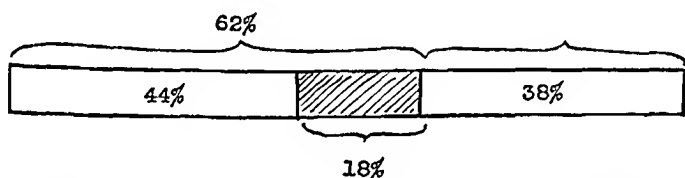


Fig. 4.—Results of treatment by the author, of 100 consecutive cases of intussusception by hydrostatic pressure. 62 per cent reduced by hydrostatic pressure; 44 per cent did not require operation; 18 per cent reduced by injection, but small incision made to verify reduction; 38 per cent required operation because intussusception not completely reduced.

some of the charcoal within six hours by washing out the bowel, it would be wise to consider the possibility of incomplete reduction.

7. *Opaque Enema as a Means of Diagnosing Reduction.*—An opaque enema can be used, and by fluoroscopy, the actual reduction of the intussusception can be followed; but as the long and mobile sigmoid and transverse colon are distended with the opaque fluid, it is difficult to see the cecum until most of the enema has been allowed to escape. This method, therefore, is not a practical one and, in my opinion, has no advantages over the simple saline injection; moreover, more time is wasted if one has to proceed to operation.

In a series of 100 cases the duration of the different groups was as follows:

- (1) Reduced by hydrostatic pressure alone.
Average duration 16 hours. There were ten over 24 hours; three over 48 hours; and one over three days.
- (2) Reduced by hydrostatic pressure followed by operation.
Average duration 17 hours. There were two over three days.
- (3) Cases operated upon because of failure of injection.
Average duration 26 hours.

which can be used, however, as a preliminary measure. In early cases, therefore, the intussusception can always be felt by abdominal palpation. After complete reduction following injection, provided the saline solution has passed into the small bowel, it would be impossible to palpate a tumor, even if one was present in the abdominal cavity, and so under such circumstances one can be quite certain that the intussusception has been reduced. When, however, it is possible to palpate a mass in the abdomen (usually in the ileocecal region), such a mass may be due either to thickened and edematous bowel following reduction or to an unreduced intussusception, and an operation will be necessary to determine which condition is present. Such an operation can usually be done through a muscle-splitting incision, similar to that



Fig. 3.—Illustrates the flaccidity of abdominal wall, after injection under pressure, where none of the injection had gone through the ileocecal valve. Such a case may or may not be reduced, but in either event, a mass remains palpable.

commonly used for the removal of an appendix. (See Fig. 3 where a mass could still be palpated after injection.)

2. *Alteration in Circumference of Abdomen.*—Measurement of the circumference of the abdomen at the level of the umbilicus before and after treatment will usually show an increase of about two inches where the intussusception has been reduced.

3. *Yellow Fecal Material in the Returned Saline Solution.*—All fecal material below the obstruction is usually blood-stained. If the second or third return contains yellow particles of feces, these have usually come from the small bowel above the obstruction.

4. *Flatus in the Return.*—Provided one is careful not to allow any air to pass into the bowel with the enema, the presence of flatus after the first injection is evidence in favor of complete reduction.

inches long could be felt about the umbilical region. Three injections were given; the first returned almost clear; the second contained a good deal of blood. After the third, a mass about two inches long was still palpable. A right muscle-splitting incision was made, and a small unreduced intussusception was present in the ileum. This was reduced with difficulty, and was found to commence about eleven inches from the ileocecal valve. The child made an uninterrupted recovery.



Fig. 5.—Abdomen distended after injection, but since palpation still revealed a mass due to a small unreduced portion of intussusception, it was obvious that the distention was not due to injection having passed into small bowel.



Fig. 6.—Same patient as shown in Fig. 5. The last portion of an ileocolic intussusception being reduced by gentle traction on ileum.

Comment.—This child was under the care of a pediatrician who had treated many cases of intussusception. He saw the case twelve hours after the commencement of the trouble but was misled because of the

SUMMARY OF RESULTS OF TREATMENT BY THE AUTHOR IN 142 CONSECUTIVE CASES
OF INTUSSUSCEPTION; 92 MALES AND 50 FEMALES

1. Sixty cases cured by hydrostatic pressure alone, no operation done:

	No. of cases
Ages 1 to 3 months	1
3 to 6 months	16
6 to 9 months	23
9 to 12 months	12
12 to 18 months	5
Over 2 years	3
	<hr/> 60

All recovered.

2. Thirty cases treated by hydrostatic pressure, followed by operation to verify reduction:

	No. of cases
Ages 1 to 3 months	1
3 to 6 months	10
6 to 9 months	9
9 to 12 months	6
12 to 18 months	2
Over two years	2
	<hr/> 30

Recovered, 29

Died, 1

3. Operation performed because of inability to accomplish reduction by hydrostatic pressure:

	No. of cases
Ages 3 to 6 months	10
6 to 9 months	15
9 to 12 months	17
12 to 18 months	4
Over two years	6
	<hr/> 52

Recovered, 46

Died, 6

Total deaths in 142 cases, 7. Mortality, 4.9%.

Since space will not permit of a description of all the cases treated, certain of them have been selected either as being typical or as demonstrating certain features which are of importance in carrying out the treatment outlined.

CASE 1.—D. H., female, aged nine months. Duration of symptoms forty one hours. A very healthy looking child. Large mass palpable in left side of abdomen. Three injections were given, but a small mass could still be felt in the right iliac region. A muscle-splitting incision was made in the right iliac region, and the cecum ascending and transverse colon were congested, evidently having been involved in the intussusception. The ileal portion of the intussusception remained, and was reduced with difficulty. It had started nine inches from the ileocecal valve. The child recovered.

CASE 2.—V. B., male, aged eighteen months. Had been ill with repeated attacks of screaming and pallor for three and one-half days. Had passed a very little blood stained mucus but no feces. Had been vomiting at intervals. A mass about eight

any reason operation has to be postponed for say five or six hours, the administration of bismuth or charcoal before attempted reduction by hydrostatic pressure might be of value in diagnosing complete reduction.

BRIEF HISTORY OF THE SEVEN CASES THAT DIED

CASE 1.—Female, aged ten months. Duration of intussusception, five hours. Three injections were given from a height of three feet six inches, followed by operation through lateral gridiron incision. The intussusception was very easily reduced. On the sixth day an abscess developed in the right iliac fossa, and the wound broke down. The pus was evacuated and a tube was introduced, but the child died of general peritonitis thirteen days after operation.

Comment.—This child died as a direct result of infection following operation. The ease with which the intussusception yielded at operation suggested that a more prolonged attempt at reduction by hydrostatic pressure would have been successful in reducing the intussusception, thus avoiding the fatal operation.

CASE 2.—Male child, aged three months. Duration of intussusception, three days. Very collapsed on admission to hospital. One injection was given and was followed by immediate operation. Intussusception was quite irreducible, and about eighteen inches of bowel were resected, followed by lateral anastomosis. Child died four hours later.

CASE 3.—Female, aged fifteen months. Patient had been under treatment for five days as a case of gastroenteritis, although from the history it was obvious that it was an intussusception from the start. On the fifth day, about five inches of the bowel prolapsed through the anus, and the real nature of the trouble was diagnosed. The prolapsed portion of the intussusception was returned through the anus, and three injections were given. These considerably reduced the size of the mass palpable in the abdomen. Operation followed through a midline incision. The whole of the large bowel was greatly thickened and edematous, and the remaining portion of the intussusception was easily reduced. The whole of the large bowel was extremely mobile, the case being one of nonfixation of the colon. It was the mobility of the colon which had prevented dangerous strangulation of the bowel and enabled reduction to be effected with such ease. The child died from shock six hours after operation.

Comment.—If this child had been given plenty of saline solution before operation, or if operation had been preceded by a transfusion of blood and if a more prolonged attempt at reduction by hydrostatic pressure had been made before resorting to operation, I believe the intussusception would have yielded without operation, and the child's life would have been saved.

CASE 4.—Female, aged ten months. Duration of intussusception, three days. One injection given, followed by immediate operation. Intussusception found to be quite irreducible. About twelve inches of bowel were resected, and Paul's tubes were inserted into the open ends. Death followed eight hours later. Examination of resected portion showed that the intussusception had commenced in the ileum about eight inches from the ileocecal sphincter.

almost complete absence of blood from the rectum. It was only after a portion of the intussusception had been reduced by the first injection that any quantity of blood appeared.

CASE 3.—K. D., male, aged five months. Had been in hospital for seven days under treatment as a case of gastroenteritis, although nothing but blood and mucus had been passed during this period. On the seventh day a tumor could be felt both through the abdominal wall and per rectum; the case was diagnosed as intussusception. The infant was extremely emaciated and was obviously too ill for any operative interference. Three other surgeons who saw this case agreed that operation was out of the question. The mass disappeared after a third injection, and there was no further sign of gastroenteritis, indicating that the case was one of intussusception from the first. The child made an uninterrupted recovery.

CASE 4.—E. B., female, aged six months. Duration of intussusception, four hours. Mass which was palpable before treatment, disappeared after injection and abdomen remained distended. One teaspoonful of charcoal was left in the stomach, and some of this was recovered by rectal lavage five hours later.

CASE 5.—V. K., female, aged seven months. Duration of intussusception, ten hours. Abdomen distended after third injection. One teaspoonful of charcoal left in stomach after treatment. Some of this recovered by rectal lavage six hours later.

CASE 6.—R. M., male, aged five years. Sudden onset with abdominal pain and signs of shock five hours before admission to hospital. Was sent to hospital as case of appendicitis. A freely movable mass could be felt in the right iliac region, and some blood was present in the rectum. The mass disappeared after injections of saline solution, but abdomen remained flaccid. Abdomen was opened through a right-sided muscle-splitting incision. The cecum and last few inches of ileum were greatly thickened, but the intussusception had been reduced.

CASE 7.—C. D., male, aged four months. Duration of intussusception, twenty-four hours. Was first admitted to medical ward, as no blood was seen after enema. Later a mass was palpable in region of hepatic flexure of the colon. This disappeared after injection, but as abdomen did not remain distended, an operation was done. The intussusception had been reduced by the injection; the cecum and ascending colon showed evidence of having been involved in an intussusception.

CASE 8.—G. H., male, aged nine months. Duration of symptoms, twelve hours. Mass palpable in ileocecal region. Three injections given, but abdomen did not remain distended, hence operation was done. A very small portion of the intussusception was found unreduced and was reduced with such ease at operation that it was quite obvious that if one had persisted a little longer with the injection, it would certainly have yielded to hydrostatic pressure.

CASE 9.—D. H., male, aged eight months. Duration of symptoms seventy-two hours. Intussusception palpable per rectum. The patient had been treated as a case of gastroenteritis and had been given a considerable amount of a bismuth preparation. After the second injection bismuth stained feces came away although nothing but blood and mucus were seen after the first injection.

Comment.—An operation was not done on this case, because the appearance of the bismuth after the injection was an indication of complete reduction. The course of events in this case suggests that if for

any reason operation has to be postponed for say five or six hours, the administration of bismuth or charcoal before attempted reduction by hydrostatic pressure might be of value in diagnosing complete reduction.

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Comment.—This child died as a direct result of infection following operation. The ease with which the intussusception yielded at operation suggested that a more prolonged attempt at reduction by hydrostatic pressure would have been successful in reducing the intussusception, thus avoiding the fatal operation.

CASE 2.—Male child, aged three months. Duration of intussusception, three days. Very collapsed on admission to hospital. One injection was given and was followed by immediate operation. Intussusception was quite irreducible, and about eighteen inches of bowel were resected, followed by lateral anastomosis. Child died four hours later.

CASE 3.—Female, aged fifteen months. Patient had been under treatment for five days as a case of gastroenteritis, although from the history it was obvious that it was an intussusception from the start. On the fifth day, about five inches of the bowel prolapsed through the anus, and the real nature of the trouble was diagnosed. The prolapsed portion of the intussusception was returned through the anus, and three injections were given. These considerably reduced the size of the mass palpable in the abdomen. Operation followed through a midline incision. The whole of the large bowel was greatly thickened and edematous, and the remaining portion of the intussusception was easily reduced. The whole of the large bowel was extremely mobile, the ease being one of nonfixation of the colon. It was the mobility of the colon which had prevented dangerous strangulation of the bowel and enabled reduction to be effected with such ease. The child died from shock six hours after operation.

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CASE 5.—Female, aged eight months. Duration of intussusception, four days. Child had been treated as a case of gastroenteritis for four days, although the history showed that this diagnosis was incorrect. The child was admitted to hospital in an extremely collapsed condition. Three injections were given, and the mass which was palpable before this treatment almost disappeared. Operation followed and the small remaining portion of the intussusception was easily reduced. It was of the ileocecal variety. The child seemed to be doing well but collapsed suddenly and died twenty-four hours after operation.

CASE 6.—Male child, aged nine months. Duration of intussusception, fifty hours. On admission to hospital, he was in an extremely collapsed condition with rapid pulse and sunken eyes. One injection was given and operation followed immediately. The intussusception was irreducible and resection was done. Death occurred three hours later. An examination of the resected segment showed that the intussusception had commenced in the ileum nine inches from the ileocecal sphincter.

CASE 7.—Female, aged ten months. Duration of intussusception, three days. Large mass palpable per rectum, and through abdominal wall. Injection given from height of three feet six inches. Abdomen became distended after injection, but operation was done on account of long history. On opening the abdomen, it was discovered that the intussusception had been completely reduced, and there were indications that it had commenced about three inches from the ileocecal valve. There was a small pinhole perforation in the ileum about three inches from the ileocecal valve, and some of the saline had escaped into the peritoneal cavity. The child died about twelve hours after operation.

Comment.—At postmortem it was found that the perforation was situated on the course of a ring ulcer of the ileum. The ulcer was evidently at the level of what had been the apex of the intussusception. In this case, my assistant had held the catheter in the bowel while I palpated the abdomen before the saline solution had drained away from the large bowel. Hence, a much greater pressure had been used than that recommended, and in addition, the bowel had been weakened by the ulceration due to the long duration of the intussusception. This case occurred as far back as the year 1923 and is the only one of the kind which I have encountered.

A BRIEF REVIEW OF THE SEVEN CASES THAT DIED

Of these seven cases that died, the duration of the intussusception in five of them was three days and over; in one, it was over two days; and in the remaining case, it was only five hours. This case was the only one in the whole series of 142 cases in which death occurred, where the duration of the intussusception was under thirty-six hours.

In three of the cases, resection was done and all died. Case 1 died of general peritonitis following infection as a direct result of the operation. Two children died from shock following operation. One child died as a result of perforation of the bowel.

A study of these cases shows, as is well known, that the most important factor in reducing the mortality rate is early diagnosis and

treatment. Where, however, an intussusception has been present for three or four days, it is far more important to apply measures to counteract the shock and to restore the loss of fluid and chlorides to the blood and tissues than to do an immediate operation.

Where reduction of the intussusception cannot be effected at operation, resection in an infant is attended by a very high mortality, but may be successful if saline injections or transfusion of blood are given beforehand.

Instead of resecting the unreduced portion of bowel, successful results have been reported by doing a lateral anastomosis and then leaving the unreduced portion of the intussusception in situ. Possibly such a procedure might have been successful in one or other of the above cases.

SUMMARY

The treatment of intussusception by a preliminary injection of saline per rectum is advocated, and evidence is adduced in favor of this procedure. Certain signs indicating complete and probable reduction are given. Then follows a brief summary of the results of such treatment of a consecutive series of 142 of the author's cases and a short history of a few selected cases.

THE THERAPEUTIC MANAGEMENT OF INTESTINAL OBSTRUCTION

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THERE is no substitute for early operation when the intestine is mechanically obstructed. All other treatment is adjunct treatment to aid in the conservation of life until the obstruction and its effect upon the patient can be relieved.

Any consideration of the therapy of intestinal obstruction would be incomplete without emphasizing the fact that there are two definite types of obstruction, simple mechanical occlusion of the bowel and occlusion with disturbed blood supply or strangulation. The latter includes obstructions incident to *mesenteric thrombosis* and *intussusception*. Disturbed blood supply adds to the immediate danger of obstruction, demanding greater vigilance and more prompt treatment. In planning treatment for obstruction of the intestine, it is important to remember that the nearer the obstruction is to the pylorus, the more rapidly symptoms will develop and the more promptly death will ensue if the obstruction is not relieved. Obstructions in the colon are much less serious than those in the small intestine and present a very different problem in treatment.

The following factors in the treatment of obstructive lesions of the intestine are worthy of separate considerations: (1) Relief of the mechanical obstruction by operation, (2) maintenance of water balance, chemical balance, and nutrition, (3) prevention and relief of distention of the bowel, (4) application of heat to the abdomen, (5) oxygen therapy, (6) bed posture, (7) transfusions.

1. *Relief of the Mechanical Obstruction by Operation.*—The time and method of operative procedure must depend upon the type of obstruction and the condition of the patient. If the obstruction is of short duration and the patient has not been seriously depleted, operation may be done at once. Other patients suffering from dehydration, hypochloremia, abdominal distention, and rapid pulse should always receive preliminary treatment with water, sodium chloride, and gastric suction before operation. While this preliminary treatment is necessary to lessen the operative risk, it is equally true that such treatment should not be prolonged beyond a few hours before surgical relief is instituted. At this point it is appropriate to warn against delaying operation in those patients who show marked general improvement as a result of supportive treatment.

Simple occlusion of the intestine can usually be relieved by directly removing or releasing the cause of the obstruction. However, certain conditions may be found or complications may arise during the progress of the operation which make it necessary to resect or repair portions of the bowel, thereby adding to the operative hazard. Stripping of the bowel to remove its contents is of doubtful value as shown both clinically and experimentally by Ochsner and Storek.¹ When emptying the bowel is desirable to reduce distention, stripping adds to the danger of infection and shock; and when the bowel is not over-distended and peristalsis is still active, stripping is not necessary.

When strangulation of the gut is suspected, early operation is imperative to avoid the toxic effect of necrosis and the danger of peritonitis as a result of rupture. Release of the constriction interfering with the circulation may be sufficient providing the surgeon is positive that the blood supply returns to the gut, insuring its viability. If irreparable necrosis has resulted, the extent of operation must depend upon the patient's general condition. Frequently it is much safer to exteriorize the necrotic segment and remove it after closing the abdominal wall, leaving the open ends of the gut protruding to be closed at a later date by anastomosis or by the Mickulicz technic. Operative procedures upon acutely distended gut are always dangerous. In a patient acutely ill with obstruction, resection and anastomosis not only consume valuable time, but the danger of peritonitis is great. Leakage from the distended gut of intestinal obstruction usually means disaster.

Enterostomy as a treatment for mechanical intestinal obstruction is always an operation of necessity and not of choice. There are indications for its uses both as a primary and as a supplementary procedure. In those patients who are too ill for exploration and release of an obstruction, enterostomy may be life-saving. After relief of an obstruction, enterostomy is often advisable to drain a markedly distended bowel or to protect a damaged gut wall or suture line. It is not free from danger. Peritonitis and abdominal wall infection may result from leakage of intestinal contents when a tube and sutures are placed in an overdistended gut wall. The danger of enterostomy may be reduced to a minimum by isolating a segment of bowel with intestinal clamps and by aspirating all gas and liquid content before placing sutures and introducing the tube. Thoughtful care must be used in selecting the proper patients for enterostomy. An error leading to a fatality may be made if enterostomy alone is done for an obstruction due to a strangulated section of the bowel. When an abdomen is opened and bloody fluid is found, the surgeon should definitely assure himself that no strangulation of the gut is present before enterostomy is done. Enterostomy will not successfully drain the bowel if it is

paralyzed. Peristalsis must be present to force the liquid and gas content of the gut through the enterostomy tube. High jejunostomy is of very doubtful value in the treatment of any type of obstruction. The logical place for intestinal drainage by enterostomy is just proximal to the point of obstruction. It is the author's opinion that the suction method emphasized by Wangensteen² is far more efficient in emptying the stomach and upper intestine than high jejunostomy.

When an enterostomy is done, the technique of Witzel or one of its modifications,² using a size 16 or 18 French rubber catheter, is the safest operation. After the catheter is fixed in the gut, it should be passed through the omentum and when possible the omentum fixed to the suture line for added protection against infection and adhesions.

2. Restoration and Maintenance of Water Balance, Chemical Balance, and Nutrition.—In any obstruction of the small intestine, dehydration soon becomes a factor of prime importance due to lack of liquid intake and vomiting. To restore and maintain a sufficient supply of water for the proper functioning of the chemical processes of the body is one of the most essential phases of the treatment of bowel obstruction. As emphasized above, the parenteral administration of water and sodium chloride should precede operation in all cases showing the effects of dehydration and should be continued after operation until the patient is able to drink and retain a sufficient quantity of water to supply the body needs.

The initial quantity of water needed varies much, depending upon the anatomic location and duration of the obstruction. The general appearance of the patient is a helpful guide. The daily intake for the normal individual under usual conditions varies from two to three liters. No accurate estimate can be made of the actual need of all cases except as they are studied individually. It must be recognized that the lack of normal intake does not represent the total loss of liquid to the body. The secretions into the stomach and upper intestine are also lost by vomiting or through the suction tube. This loss may at first amount to several liters per day (Fig. 1).

By clinical experiments, Maddock and Coller³ have been able to estimate with considerable accuracy the fluid needs of the dehydrated patient. When a patient is first seen with signs of dehydration, such as a hot dry skin, a dry tongue, sunken eyes, rapid pulse, a slight fever, and insufficient urine output, these authors have estimated that there has been a loss of liquid approximately equal to 6 per cent of the body weight. A patient weighing sixty kilograms would therefore require 6 per cent of 60,000 gm. or 3,600 c.c. as an initial supply of water to relieve existing dehydration. The quantity of water estimated for the daily uses of the adult body are two liters for water

of vaporization (loss through skin and lungs) and one and one-half liters for urine. It is, therefore, evident that a seriously dehydrated patient would require in the first twenty-four hours 3,600 c.c. plus 2,000 c.c. plus 1,500 c.c. to restore and maintain water balance. In addition to this requirement, any losses by vomiting, bleeding, fistulas, diarrhea, or massive exudation should be estimated and the quantity restored to the body. After the initial supply of water, the average daily, necessary intake for adults may be estimated as 3,500 c.c. This quantity should be decreased as the patient is able to retain food and liquid given by mouth.

Circulation of Gastro-intestinal Secretions

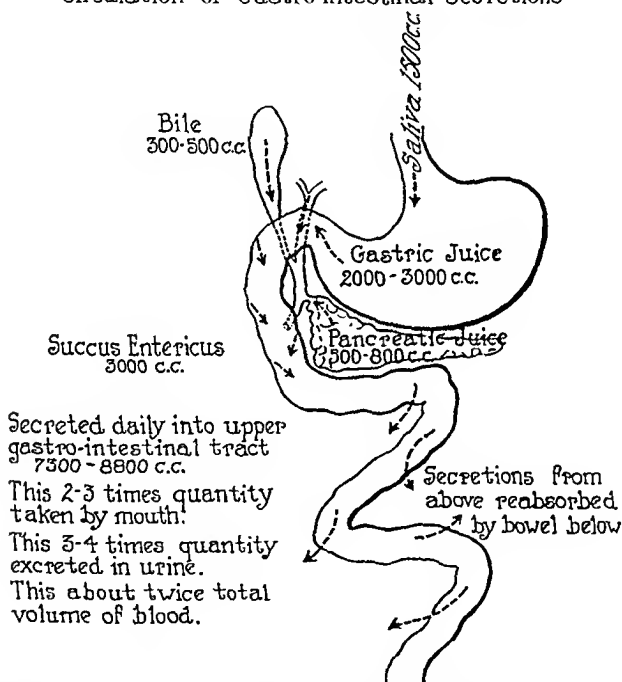


Fig. 1.—Sketch illustrating a circulation of the alimentary tract secretions. This shows the possibility of great fluid loss with obstructions high in the small intestine.

Obstructions of the intestine causing a loss of upper alimentary tract secretions are often associated with marked chemical changes in the body which may be demonstrated by blood examination. This loss is particularly marked if the obstruction is high or prolonged. The important blood changes are a loss of chlorides (hypochloremia) and increases in carbon dioxide combining power and an increase in the nonprotein nitrogen. After prolonged starvation, a disturbance in nutrition may be sufficient to decrease the blood serum protein.^{4, 5} Chemical changes assume less importance in those cases in which there

is early relief of the obstruction and in colon obstructions. The best gauge of the extent of body chemical change is an estimation of the blood chlorides. In the treatment of intestinal obstruction, the blood chlorides should be restored to normal and maintained within normal limits. By so doing, the acid-base imbalance is corrected, destruction of body protein minimized, and proper water distribution to the body tissues assured. After a marked reduction has occurred in the blood serum protein, excessive quantities of sodium chloride may result in edema of the subcutaneous tissues or edema of the lungs.

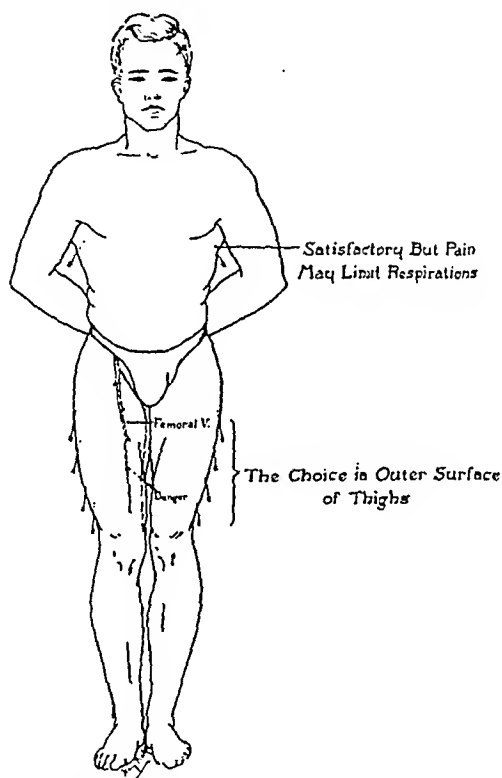


Fig. 2.—Sketch showing choice of location for giving hypodermoclysis.

It is quite evident that metabolic equilibrium cannot be maintained when food cannot be taken by mouth and utilized by the body in a normal manner. It is also quite true that food supply is of much less importance than water supply in the treatment of intestinal obstruction. However, dextrose may be freely given to such patients and will partially furnish the needed nutrition.

Water, sodium chloride, and dextrose may be given in the vein (phlebotomy), under the skin (hypodermoclysis) (Fig. 2), and by rectum (proctoclysis). Water alone should never be given in the vein.

Water is most safely given as physiologic solutions of sodium chloride or dextrose. Patients entering the hospital with marked hypochloremia may be given 250 to 500 c.c. of $2\frac{1}{2}$ or 5 per cent sodium chloride solution by vein to promptly restore the chlorides to normal. In most cases a physiologic solution will suffice. Dextrose in 5 per cent solution is preferable to higher percentages to avoid the dehydration effects of hypertonic solutions. It is unwise as well as unnecessary to give hypertonic solutions under the skin. Subcutaneous tissues tolerate well physiologic sodium chloride solution alone or in combination with 5 per cent dextrose. Ringer's or Hartman's solutions may be used instead of the plain sodium chloride solution and are preferred by many clinicians. Of the methods cited above for administering solutions, phlebotoclysis and hypodermoclysis are, from the standpoint of quantitative accuracy, more dependable than proctoclysis. Proctoclysis is satisfactory when it works properly, but too frequently the solution is expelled by the sick patient and an accurate estimation of the body intake is impossible. The discomfort incident to increased distention by water introduced into the rectum is also a valid reason for not using proctoclysis. It is also doubtful if dextrose is absorbed by the large bowel in sufficient quantity to be of value.⁶

Solutions injected by any of the three methods under discussion should be given slowly. Fluids given by vein may be safely administered at the rate of fifty to sixty drops per minute. The rate of absorption under the skin varies widely with different patients and should be controlled by preventing tumefaction of the part. A rapid instillation into the rectum will stimulate expulsion and loss of fluid. A very satisfactory routine method of supplying the estimated daily requirement of 3,500 c.c. of fluid is accomplished by injecting 2,000 c.c. into the vein and 1,500 c.c. under the skin. To distribute the intake throughout the day, one of these injections may be given in the forenoon and the other in the evening. The injections should be discontinued at night to avoid disturbing the patient's rest. Since embolism is considered by many a dangerous complication of continuous phlebotoclysis,^{7, 8} intravenous injections in interrupted doses are preferred. To control the salt intake the blood chlorides should be estimated every second day. If the blood chlorides are found normal or above normal, dextrose solution alone should be given until the need of sodium chloride is evident.

There is some danger of giving too much water and sodium chloride. The overburdening of a weakened circulatory system by increasing the blood volume⁹ or the production of a general edema and edema of the lungs¹⁰ must be avoided. Too much sodium chloride predisposes to general and pulmonary edema.

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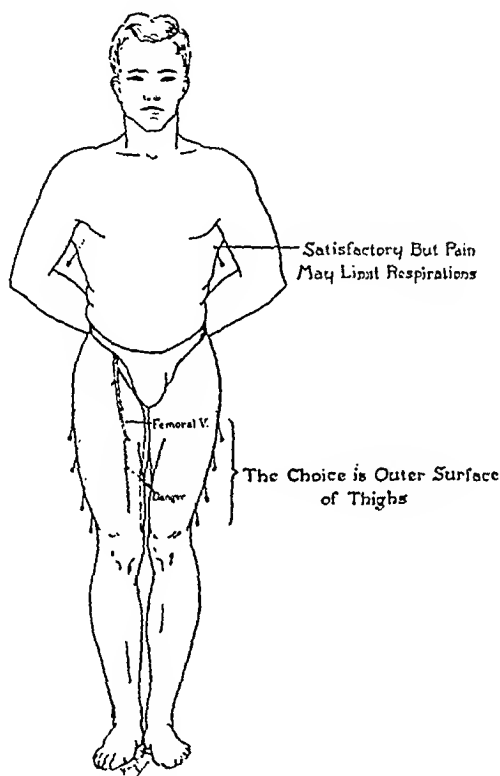


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generally causes very little discomfort and may be left in place for several days. The indwelling tube is also of value in testing the return of bowel function. It may be clamped at two- or three-hour intervals when liquid diet is started to determine the tolerance of the bowel for liquid and food. If the aspirated quantity at the end of the closed tube period is less than the intake for that period, the tube may usually be safely removed.

Attempts to reduce distention by repeated enemas are of doubtful value. Enemas should be used with a full realization that gas and feces obtained from the colon by such measures may in no way affect the obstructed bowel above. One must beware of a feeling of false security which might arise after a successful evacuation of the lower bowel. Experiments have shown that the type of enema commonly used does not stimulate peristalsis in the small intestine and cannot be expected to aid in its evacuation.¹⁴

Enterostomy as discussed above has its value in the mechanical reduction of intestinal distention.

By preventing and reducing distention of the gut, muscle tone and rhythmic contractions are maintained. As long as a bowel retains its power to contract, the blood supply to its walls is intact. A bowel wall cannot be active without an adequate circulation. Since morphine stimulates the tone and rhythmic contractions of the small intestine,^{15, 16} it may be given with assurance in sufficient quantity to make the patient comfortable. Since sodium chloride in hypertonic solutions will stimulate peristalsis, it is reasonable to assume that it may be a factor in maintaining bowel tone when given in physiologic solution in sufficient quantity to maintain the chlorides at a normal level in the body.

The use of spinal anesthesia to evacuate the bowel is a rather drastic treatment and of doubtful value. It certainly should never be used for this purpose as long as the bowel is obstructed. Pituitary extract and similar peristaltic stimulants should be used with caution and like spinal anesthesia should not be used as long as obstruction exists. If peristaltic stimulants are used after the obstruction has been released, it is advisable to begin with small doses and increase the dosage if well tolerated. It is the opinion of Ochsner¹⁷ that stimulating drugs are of little or no value in the treatment of ileus.

4. *Application of Heat to the Abdomen.*—Moist or dry heat applied to the distended abdomen is beneficial when judged by clinical observation. It is believed by some authors that heat has a direct effect upon the gut by increasing tone and stimulating peristalsis.¹⁷ Since no known harm results from applying heat, if blistering is avoided, its use is recommended. Heat applied either as moist packs or as dry

3. *Prevention and Relief of Bowel Distention.*—A proper appreciation of the danger of overdistention of the bowel is essential for logical treatment. A patient is usually not dangerously ill unless there is marked distention of the stomach or intestine. Increased pressure within the lumen of the gut seriously interferes with the blood supply of its wall.¹¹⁻¹³ It is probable that there is no absorption of toxic products from the contents of the obstructed intestine until overdistention has damaged the circulation of the gut wall.

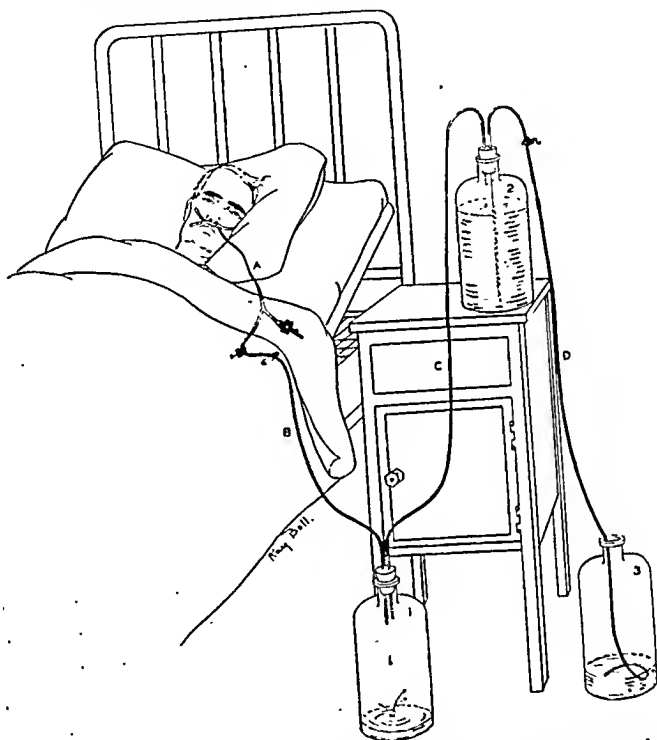


Fig. 3.—Suction apparatus, a modification of suction apparatus described by Wangenstein. A, Levin tube and Y-tube attached for ready cleansing with syringe; B, rubber tube leading from patient to waste bottle, 1; C, rubber tube connecting waste bottle with water supply bottle, 2; D, rubber tube connecting water supply with overflow water bottle, 3. Bottles 2 and 3 are interchangeable to avoid new supply of water when 2 runs low. Tube D is kept filled with water with lower end immersed in water of bottle 3 to maintain continuous suction.

To relieve distention in the stomach and upper small intestine, continuous suction drainage by an indwelling nasal Levine tube is indicated. Siphonage with suction is superior to simple siphonage, since the former will more readily and completely evacuate the gases as well as the liquid content. The apparatus designed by Wangenstein² or one of its slight modifications (Fig. 3) is ideal for this purpose. This method not only reduces the distention but permits the patient to drink water freely which adds greatly to his comfort. The nasal tube

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heat from electric bulbs over the abdomen seems to be equally effective and may be used as the surgeon's choice dictates.

5. *Oxygen Therapy*.—Oxygen is probably too little used in serious cases of intestinal obstruction. With abdominal distention and changes in blood composition, the vital capacity of the lungs and oxygen carrying capacity of the blood are decreased. The recent work of Fine and his associates¹⁸ presents a new viewpoint in oxygen therapy that may prove to be of value in reducing abdominal distention. They found that the absorption rate of gas within the bowel is increased in direct proportion to the quantity of oxygen given. Thalhimer¹⁹ emphasizes the teaching of Haldane that mild degrees of anoxemia have serious effects upon the nervous system and moderate or severe degrees may be fatal. Oxygen therapy administered by tent, nasal tube, or oxygen room is recommended for patients who are very ill with intestinal obstruction. The administration of oxygen should not be postponed until the patient is cyanotic or the condition seems hopeless.

6. *Bed Posture*.—Comfort and vital capacity are increased by raising a patient's back rest to a semisitting posture. This position may be altered at intervals to rest the patient. Deep breathing and frequent turning of the patient are important to minimize the danger of congestion at the lung bases.

7. *Transfusions*.—The transfusion of blood as a supportive treatment for patients with bowel obstruction has been favorably recommended. It is especially indicated after an illness of several days when protein depletion is imminent.

SUMMARY

It is emphasized again in conclusion that there is no substitute for early operation when the intestine is mechanically obstructed. Inflammatory obstructions due to paralysis or recent adhesions between loops of bowel may spontaneously release themselves with control of distention and other supportive treatment.

Extensive operations upon an acutely obstructed bowel are hazardous except in the early cases. The briefest operation with the least possible trauma is the procedure of choice. It is in this type of obstruction that enterostomy not only may be life-saving but also may be frequently the only operative procedure necessary.

When a very early diagnosis of obstruction is made and obstruction successfully relieved by operation, much of the treatment outlined above may be unnecessary. In very late cases all treatment may be of little avail. In an active surgical practice there are sure to be all types of obstructive lesions and to say that any one outline of treatment applies to all would be folly.

pens to be noted or borborygmi are picked up by the stethoscope. The white blood count frequently will be elevated, but the absence of tenderness or spasm tends to give the physician a false sense of security. No trouble will occur for a period of hours depending upon the level of obstruction. Then, there will be a repetition of the attack. This latent period of freedom from symptoms often throws the unsuspecting physician off his guard and retards his diagnosis. The latent period results because of the time that it takes for the bowel above the obstruction to again become filled with secretions. In the objective obstructed or strangulated hernias, of course, there are no difficulties of this kind.

It is in the patients who have passed the first forty-eight hours from the onset of their obstruction that it is exceedingly difficult to make a prognosis. The small bowel usually has distended quite considerably by this time. The contents within it have become foul, stagnant, and toxic. There is no way for the surgeon to decide with certainty whether he is dealing with a strangulated loop or not. The temperature may be normal or subnormal; and the pulse may be slow. It is possible to judge that the patient is beginning to get toxic by manifestations of discomfort and a worried expression. There may be a slight flush at times. The patient becomes restless. He may drowse off for periods only to rouse and thrash about. The tongue looks red and dry. The vomitus begins to get a fecal odor. The white blood count is high—out of proportion to the abdominal signs. The inexperienced surgeon is more likely to underestimate the severity of the condition of his patient than to really evaluate it. He is surprised to find how high the nonprotein nitrogen of the blood is recorded in the chemical laboratory. If he operates, he may undertake a more extensive procedure than is necessary. He should remember that usually following operation the general condition will be worse for some hours, as can be observed by changes in the temperature, pulse, and chemistry of the blood. It is just here that the surgeon of experience can tell that the patient is much sicker than he appears to be. He will not be able to state why he thinks so, if pressed by his colleagues. If the patient has gone beyond the forty-eight- to seventy-two-hour period without manifestations of grave toxicity, it is usually an indication that strangulation is not present, and that the loops are being successfully decompressed either through vomiting or suction drainage. It is well, however, for the surgeon to keep in mind in the early period of an obstruction that he probably is dealing with a strangulation as he has no means of knowing it except by exploration (Case 1).

If the diagnosis of complete intestinal obstruction can be made at the onset of the symptoms, the sooner surgery is undertaken the better.

FACTORS DETERMINING THE SELECTION OF OPERATION IN OBSTRUCTION OF THE SMALL INTESTINE

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THERE is no more severe test of a surgeon's ability than in the decisions he makes regarding the treatment of intestinal obstruction. The factors which influence his judgment in any given case are many and varied. The general condition of the patient, the time since onset, the cause of the obstruction, the level of the obstruction, the local condition of the obstructed bowel, the changes in the chemistry of the blood—all must be given serious consideration. Then, in addition, there remain certain intangibles which the older surgeon cannot define but which he recalls from past experience of similar circumstances.

The general condition of the patient at the time of entry is, without doubt, the most important single factor in determining what type of operation, if any, can be tolerated. The patient's condition is essentially the resultant of all the factors mentioned in the first paragraph above. Under certain circumstances, the combinations of these factors have led to such a state that a lethal outcome cannot be avoided by any therapy at present available. Hence it becomes a prime necessity for the surgeon to be able to estimate how sick his patient really is.

There will be little difficulty in the very late toxic patient. He will be either in the stage of exhaustion with a grayish pallor; darkly circled, sunken, dull eyes; anxious, drawn, fatigue lines about the mouth; drowsiness; fecal odor to the breath; overflow type of regurgitant vomiting; distended, silent abdomen; and cold, clammy extremities: or in the stage which just precedes it, when his pulse will be rapid, his temperature high, and his face flushed and unhappy. He may be restlessly thrashing about the bed when the painful cramps have not yet given way to the paralytic stage. In neither of these stages is operation likely to be of any value.

In the early stages within a few hours after the onset of symptoms, there will be also little difficulty in making a decision. There has been but slight change in the patient's general condition at this time. The only real danger is from deciding that nothing serious is wrong. The patient has had crampy pains followed by repeated vomiting. Examination gives practically no information, unless visible peristalsis hap-

Meckel's diverticulum, obstructions of loops through tears in the mesentery, and internal herniations fall into this latter group. Strangely enough the obstructions which follow recent surgical interventions rarely are picked up early by the surgeons in attendance. The vomiting in the first week or ten days after operation is assumed to be natural for certain patients. The crampy pains are believed to be gas pains only. It is hard for the surgeon to realize that such a calamity can follow one of his operations. The diagnosis thus is made with reluctance. On the other hand, obstructions in the presence of peritonitis are expected. If such a patient passes the two weeks' period without obstruction, it is considered fortunate. Both these latter type obstructions offer a fairly favorable prognosis, however, for frequently it is possible to carry them on suction drainage until the adhesions are absorbed. The high obstructions about the mesentery in infants are usually partial; they constitute a class in themselves, requiring special handling. Obstructions occurring in pneumococcic, streptococcic, or tuberculous peritonitis are conditioned by the severity of the general infection (Case 2).

Generally, it is thought that high obstructions are more dangerous than low ones. From experimental work it has been concluded that the nearer the obstruction to the bile ducts, the more severe is its character. It is our experience that this is not so unless a short high loop is strangulated. The high obstructions are more easily controlled by suction drainage than the low ones. The salt and water balance constitutes the main difficulty in the high obstructions. This can be restored quite readily, after which the toxicity as measured by non-protein nitrogen approaches normal. The low obstructions sometimes also do well, but there is more opportunity for some loops to twist and become trapped. The plasma volume must be taken into consideration under such circumstances.

The condition of the blood supply of the bowel is of the utmost importance. Strangulation with gangrene modifies the prognosis more than any other single factor as far as surgery is concerned. The surgeon can only hope that the bowel segment will recover when once its circulation has been released from the obstruction. Under hot packs, the bowel should be watched for fifteen to twenty minutes. Signs usually regarded as favorable for viability are: return of reddish color, return of pulsation in the vessels, appearance of a glistening surface on the visceral peritoneum, and peristalsis on stimulation. If the loop does not show these changes, it is usually safer to resect it. Resection should be carried well beyond the damaged bowel into healthy tissue to avoid small thromboses in the vessels. The more extensive the resection is, the more difficult the surgery, with conse-

There should be no mortality from these early operations. It is the ideal time for operation in intestinal obstruction. There are many reasons why operation is safer at this time. The principal reason is that there has been little change in the patient's general condition so that operation is performed under better circumstances. The loops have not become distended to any degree so that they do not get in the way. The obstruction is easier to find and to handle. There is less danger of impairment of the circulation to the bowel. There is less loss of fluids and salts. The bowel can be manipulated more safely without fear of rupture. Spinal anesthesia can be selected unless contraindicated for other reasons with fear of tearing a damaged loop by its use. The recovery after operation in these cases should not be different from that which follows any other abdominal operation.

It may be proper to ask what is the safe period of time to watch a patient without risking a gangrene of the bowel if its circulation happens to be cut off. This is a difficult question to answer. There is really no surely safe period for observation. In an occasional instance, the bowel will be damaged irreparably after three hours of strangulation of its blood supply. On the other hand, a complete cutting off of the circulation may be tolerated for as long as from six to ten hours. There have been cases where the circulation must have been shut off intermittently for much longer periods with eventual recovery of the bowel. Owing to the uncertainty, it is wiser to play on the safe side and not set any limit but to proceed as soon as is expedient. Also, this uncertainty is a very powerful reason for not attempting to reduce an obstructed hernia under average circumstances.

The surgeon is not often called upon to treat intestinal obstruction in the ideal time period, i.e., within the first six to twelve hours. It is usually his lot to have to deal with much later obstructions. If the first forty-eight hours have passed, time should be taken to get the patient into better condition if possible. This can be done by decompression of the obstructed loops by the use of Wangensteen suction drainage. The blood chemistry can be studied and the deficiencies made up as indicated. Salt, sugar, or blood can be given; and drugs so that the patient can be rested until ready for surgery.

When the cause for the obstruction is obvious, the prognosis is usually good. For this reason, obstructed hernias are recognized quickly and operation is done in the favorable period. The same is true for intussusception in children, unless there is doubt about the diagnosis. It is also fairly common to get a reasonably early diagnosis in patients who have obstructions about old adhesions from previous abdominal operations. When the diagnosis is obscure, delay is frequently responsible for a poor prognosis. In consequence, the obstructions due to mesenteric thrombosis, intussusception in adults, volvulus about a

geon should have the ability to adapt himself to whatever he finds. Sometimes a sidetracking operation will be the most simple solution of a complicated situation. Care should be taken to minimize trauma and to cover raw areas so that future obstructions may be prevented. At times in chronic recurring obstructions, it will be necessary for the surgeon to use all his ingenuity and versatility in attempting to solve the problem (Case 5). When obstruction has occurred repeatedly about the same area of the intestine, it is sometimes the best surgery to perform a radical resection of this region. The tendency to repeatedly obstruct is usually based upon a pathologic process. Removal of the diseased tissue in such a case is the best insurance against future obstructions (Cases 4 and 5). The type of anesthesia best adapted to the individual should be chosen. It is fortunate that there is now such a wide latitude of choice. When spinal anesthesia can be used, it makes the surgery much easier from a technical standpoint. The inhalation anesthetics are to be avoided whenever it is possible without sacrifice.

Six case reports are appended to illustrate problems which may arise in the selection of the proper care for patients with obstruction of the small intestine.

CASE 1.—C. E., No. 123661, a boy seventeen years of age, was admitted to the Rochester Municipal Hospital on January 20, 1937. Six days previously he had a sore throat not accompanied by chills or fever. The following day there was a constant severe abdominal pain around and above the umbilicus. The bowels failed to move and numerous enemas were not effectual. He had vomited three to four times daily since the onset of pain. The pain was not crampy in character. One year previously he had had a gastrointestinal upset but except for frequent constipation, no other trouble referable to the gastrointestinal system. His father had died of pulmonary tuberculosis three years before, but he had not been exposed to it. He worked hard himself and did not get enough sleep. He fatigued easily. He had felt run down for about one year. For one month he had had night sweats. There had been no cough or afternoon fever.

Examination showed temperature, 37° C.; pulse, 70. He did not appear ill, although he was dehydrated. The throat showed acute tonsillitis and pharyngitis. The abdomen was markedly distended, tympanitic, and tender in all quadrants on pressure. Intestinal patterns were visible, and borborygmi were heard by some observers but not by others. A fluid wave and shifting dullness were noted. The white blood count was 15,050. Some observers thought that he looked acutely ill. There were comments in the notes on his restlessness. Other observers thought that he was drowsy. The general impression was that of discomfort and worry on the part of the patient.

He was placed on duodenal tube drainage. The fluid drainage from the tube had a decidedly fecal odor. Temperature was recorded as subnormal, and pulse remained at 70. The nonprotein nitrogen of the blood was 66, and the chlorides were 386 mg. per cent. Flat plate of the abdomen showed enormously distended loops of small bowel filled with fluid, definite levels being depicted. He was given intravenous salt and glucose. At operation under spinal anesthesia, volvulus was found to have occurred about the fibrous cord of a Meckel's diverticulum completely obstructing the small bowel down to that level. Upon division of the cord, deep vigorous peristalsis occurred in the obstructed bowel. The diverticulum was removed and the base in-

quently more damage to the patient in shock, etc. Even so, as much as twelve to thirteen feet of bowel, amounting to over half of the small intestine, have been resected with recovery.

When the bowel appears to be able to survive, it should be returned to the abdominal cavity. There is always an element of danger in doing this as is evidenced by Cases 3 and 4 which were handled by experienced surgeons and thought to be viable.

Aside from the blood supply, the amount of distention in the small bowel is of importance. This is more so from the recovery standpoint than from the influence on the type of surgery. It is amazing how much the small bowel can be stretched and yet recover its function. There is, of course, a certain amount of paralysis from overstretching the musculature. This causes a degree of paralytic ileus which must be taken into consideration with every severe, long-standing small bowel obstruction. The damage may be permanent in some cases, but some degree of slow recovery is the rule.

The surgeon who can follow the chemistry of the blood in his patients gets information of great value. He finds that the strangulation obstruction cases do not suffer so much from salt loss as they do from loss of plasma volume. Thus he makes ready for transfusion instead of giving his patient too much salt which may be harmful. The patients who lose many of their upper intestinal secretions through vomiting, on the other hand, require restoration of salts and water. When once the bowel begins to resume its function, blood chemistry studies need not be carried further.

There are certain surgical principles which should be applied to any case of small bowel obstruction. The surgeon should operate only under circumstances as favorable as they can be made. Nothing more should be done than is absolutely essential to restore the bowel to its normal relationships. The removal of an appendix or a Meckel's diverticulum is usually unnecessary and subjects the patient to an added risk when he already has about all that he can care for (Case 1). The simplest procedure which will relieve the situation is the best surgery. Gentleness in manipulation of the bowel will diminish the postoperative discomfort. If the surgeon will trace the collapsed loops upward from the ileocecal region to the distended intestines, he will do less damage to his patient. When a loop with a damaged blood supply is found, after release it should be wrapped in warm gauze packs and observed. If it appears to be recovering, often it may be returned with more safety than it can be resected. In case of doubt, resection should be done. Gangrenous patches can be turned in locally without a more elaborate procedure. Massive gangrene of a loop forces the hand of the surgeon and makes him do more extensive procedures than he would choose under the circumstances. The sur-

had been given. These abscesses were drained. She went home in good condition on January 12, 1934. She had had no further trouble with her intestinal tract when examined one year later.

This case illustrates the value of being able to estimate the general condition. If the surgeon had operated upon this girl when she was suffering from a general peritonitis, he would have had a fatality without any doubt. Operation would have accomplished nothing. The bowel was in a state of paralytic ileus. Enterostomy, the simplest procedure, would have been useless. By waiting until she had reacted to her infection and had partly overcome it, the surgeon was able to call to his aid all the factors of acquired resistance to the infection. When definite localizing signs of an organic obstruction were present, there was a definite indication for action. The bowel had recovered its tone. Release of the adhesions restored the intestine to its normal relationships and function.

CASE 3.—B. C., No. 119,592, a woman, forty-two years of age, was admitted to the Strong Memorial Hospital on September 22, 1936. One month previously, she had been operated upon for acute intestinal obstruction. At this time she was very toxic after forty-eight hours of crampy pains, obstipation, and vomiting. She was stuporous; and she had abdominal distention, fecal vomiting, and a pulse rate of 130. At operation a loop of small bowel had strangulated about the point of attachment of a previous uterine suspension. The bowel was released. It was quite dark, but the circulation returned so that it appeared adequate. She recovered under suction drainage until the third day. Pneumonia developed then, and it was necessary to keep her in an oxygen tent for twelve days. On the fifth postoperative day, her wound began to discharge. The local physician opened it wider. It has discharged fecal material since then. Two weeks before entry she began to run fever. A fullness developed in the right lower quadrant. Upon admission, an abscess in the right lower quadrant was drained through a McBurney incision. There was a finger-sized opening in the bowel at the bottom of the abscess cavity. Following drainage the abscess cavity obliterated, and the fecal fistula gradually became smaller. It finally closed.

This patient illustrates the danger inherent in returning a strangulated loop, which appears to have recovered. The surgeon used good judgment at the operation as the patient was in a critical condition. But some portion of the bowel failed to live. The resulting fecal fistula and localized abscess may be responsible for future trouble.

CASE 4.—E. W., No. 109272, a woman, forty-three years of age, was admitted to the Strong Memorial Hospital on December 4, 1935. There had been a sudden onset of severe crampy pains in both lower quadrants twenty-four hours prior to admission. There was temporary relief following the passage of four to five loose stools but a return of painful cramps about ten hours later. The cramps became worse as time elapsed. There was nausea but no vomiting. She had passed a little gas with an enema at the onset of the attack but none after that. In her previous history, there had been three laparotomies for pelvic and appendiceal disorders. Seventeen years ago on the eighth day after a cesarean section, her bowel had obstructed, necessitating an operation for release of adhesions. Since that time she had been free from

verted. The obstruction was relieved by the passage of the intestinal contents while on the operating table. Transfusion was done following operation; also, fluids were supplied. Suction was continued. The nonprotein nitrogen had dropped to 50 on the next day, and the chlorides were 574 mg. per cent. On the second day post-operatively, the nonprotein nitrogen was 37 and the chlorides 491 mg. per cent. Suction drainage was discontinued. Temperature which had risen to 38.5° C. dropped slowly to normal during the week. His bowels moved spontaneously or by enemas daily following operation. He had a smooth convalescence and was discharged well on February 4, 1937.

This case illustrates the difficulty in arriving at a diagnosis when there are other possibilities to consider. He was seen by several surgeons before the diagnosis was made. Even then his condition was thought to be better than the blood chemistry studies showed it to be. At operation, the surgeon relieved his obstruction by dividing the fibrous cord of the Meekel's diverticulum. He could not resist the temptation to remove the diverticulum. This is meddlesome surgery in the presence of acute obstruction. It exposed the patient to the danger of a peritonitis. The obstruction was relieved when the cord had been divided. The removal of the diverticulum added a risk which should not have been taken.

CASE 2.—S. V., No. 83048, a girl, ten years of age, was admitted to the Strong Memorial Hospital on November 27, 1933. She had been well until November 24, 1933. At this time, she developed a severe chill and headache. This was followed by spasmodic abdominal pain. The pain was low in the midabdomen and excruciating in character. There had been no nausea or vomiting. Upon examination, it was apparent that she was acutely ill and toxic. Temperature reading was 104° (40° C.) and pulse rate, 146. The tonsils were reddened. The abdomen was very tender to palpation in both lower quadrants. There was slight spasm of the abdominal muscles but no real rigidity. There were undoubted signs of peritoneal irritation but no evidence of perforation of a hollow viscus. The urine was loaded with pus. There was a slight vaginal discharge. The white blood count was 35,000. The degree of prostration and the general reaction seemed out of proportion to the peritoneal condition. This indicated that the abdominal signs were merely part of a generalized process, either a streptococci or a pneumococci peritonitis. It was decided to do an abdominal paracentesis to see if the type organism could be recovered. Otherwise she was to be watched and to be given supportive treatment. Laboratory examinations showed throat culture, 50 per cent streptococci; vaginal culture, *Streptococcus hemolyticus*; repeated blood cultures, no growth; peritoneal fluid, *Streptococcus hemolyticus*. She also showed some patches of pneumonia in both lower lung fields within a few days after entry. During the next two weeks she was very ill. She became distended, had nausea and vomiting; also, fluid appeared in both pleural spaces. The pleural fluid was spontaneously reabsorbed, but signs in the abdomen suggested localization of an abscess with beginning intestinal obstruction. Accordingly on December 7, 1933, under avertin and local anesthetic, a Mc Burney incision was made. The ileocecal valve was identified and a collapsed loop of bowel traced back to some adhesions on the lateral wall of the right pelvis. When these adhesions had been released, the collapsed loops filled with contents from above. There was a marked plastic exudate and about 50 to 75 c.c. of fluid were present. Closure was made without drainage. Postoperatively she made a good recovery except for the localization of abscesses in each thigh where hypodermic

tions. Unless the inflammation completely resolves, it leaves an area of damaged intestine with chronic inflammation, edema and fibrosis, and the formation of protective inflammatory reactions in the neighborhood. This furnishes an ideal background for another obstruction.

CASE 5.—M. D., No. 38839, a woman, nineteen years of age, was admitted to the Strong Memorial Hospital on October 20, 1931. She was operated upon for supposed acute appendicitis, but instead calcified lymph nodes were found. One of these was removed. Microscopically, it showed old tuberculosis. About one month later she began to have attacks of crampy pains, vomiting, distention, and joint trouble. The attacks were intermittent in character. There would be days of complete relief. She was followed closely in the hospital for about six weeks, two conditions being seriously considered—tuberculous peritonitis and partial intestinal obstruction. The attacks became progressively more severe until it became necessary to explore. Dense adhesions were found almost completely obstructing the midileum. There were also other loops kinked and twisted by adhesive bands between them. At one point a small volvulus had occurred about an adhesion. All these conditions were corrected. The abdominal scar in this patient was keloidal in nature and the tendency to form scar was marked. One week later because of failure to improve, she was operated upon a second time. The loops of bowel were densely matted together at the lowest point of obstruction previously noted. Even when these loops had been released there was so much scarring in the mesentery that they tended to resume their old kinked relations. Accordingly a lateral anastomosis was made around them. After a slow recovery and a prolonged convalescence during which she had complaints referred to the gastrointestinal, neurologic, and genitourinary systems, she was discharged from the hospital on February 28, 1932. She continued to have pains in the joints but had no further gastrointestinal upsets until October 13, 1932. At this time she had an attack of abdominal pain and vomiting which progressed to complete obstruction. Exploration on October 15, 1932, showed many adhesions and a band obstruction rather high in the jejunum well above the anastomosis. At closure, 50 c.c. of amfetin was left in the peritoneal cavity in the hope of preventing adhesions. She gradually recovered and was discharged on November 1, 1932, free from complaints. She was readmitted two days later with a return of symptoms. Upon failure to improve, the abdomen was explored again on November 5, 1932. Many adhesions were present involving 3 or 4 feet of the terminal ileum in kinks, much of the trouble being due to adhesions across the mesentery.

For the next two months she continued to have discomfort alternating with periods of freedom. The condition, however, gradually went on to complete obstruction. On November 20, 1932, for the fifth time operation was done because of obstruction. A mass of pathologic small bowel loops 3 feet in length was resected and an end-to-end anastomosis made between healthy jejunum and terminal ileum. A broad piece of rubber dam was left between the undersurface of the incision and the bowel. It was brought out as a drain at the lower end of the wound. It was hoped in this way to prevent adhesions to the peritoneal side of the incision. The excised specimen showed a greatly thickened mesentery with subacute inflammation of the bowel. There were no tubercles or epithelioid cells identified. She began to have obstructive signs once more about three weeks after operation. The sixth operation, on December 14, 1932, showed a definite obstruction at the site of the end-to-end anastomosis. The bowel was tied in a complicated inflammatory reaction at this point. The simplest way to relieve the obstruction seemed to be by a lateral anastomosis between the dilated ileum above the obstruction and the ascending colon. This was done. She improved until January 20, 1933. At this time she had diarrhea, vomiting, abdominal cramps, and signs of an imminent obstruction. Conservative measures were adopted—

symptoms. Upon examination at entry, she appeared to be in moderate pain. There was distention of the abdomen. Peristalsis with a definite small bowel pattern was visible in the right lower quadrant. Many abnormal peristaltic sounds were easily heard through the stethoscope. The temperature was 37°; pulse, 76. The white blood count was 12,000. A scout film of the abdomen showed a loop of small bowel distended with gas in the right pelvis. A duodenal tube was inserted and 400 c.c. of greenish fluid with a moderate amount of gas was recovered. There was some relief from this procedure, but the white blood count rose to 16,000.

At operation two hours later, there was a large amount of slightly cloudy non-odorous fluid in the peritoneal cavity. Several loops of small bowel were bound down in the pelvis by long dense fibrous adhesions, stringy in character. These were released. When this had been done, it was apparent that there was a badly obstructed loop of a deep purplish plum color buried under a mass of adhesions in the pelvis. These adhesions were attached to the posterior wall of the bladder and to some remnant of her pelvic organs. When the adhesions had been dissected from the bladder, it was possible to bring up the intestinal loop. The obstructed bowel was about 12 inches (30 cm.) from the ileocecal valve. Although the discoloration of this loop was considerable, in about ten minutes under hot gauze packs it became reddish purple, and pulsations could be seen returning in the vessels. There were no areas of frank necrosis. The bowel wall glistened and peristalsis could be started by gentle pressure on the segment. Accordingly, it was decided that the loop was viable. Closure was made. Recovery from operation was quite satisfactory. The day after operation the nonprotein nitrogen had fallen from 38 to 28 mg. per cent. She was discharged to her local doctor on the tenth day after operation. The wound was well healed. A smooth nonresidue diet and the use of mineral oil were recommended. She was readmitted twelve days later because of recurring abdominal pain. Two days previously there had been a sudden onset of sharp crampy pain in the right lower quadrant. This passed off but returned again twenty-four hours later. Four hours before admission it became quite severe. She again presented the signs of an acute intestinal obstruction. At operation, the ileum was found densely adherent to the anterior abdominal wall about 10 to 12 inches from the ileocecal valve. These adhesions were dissected free; in doing so, a small quantity of clear, odorless fluid seemed to come from a perforation in the loop. Accordingly, the involved loop which was narrowed and scarred by fibrous adhesions was resected and an end-to-end anastomosis made. Examination of the resected segment showed a dusky narrowed circular fibrosed area with a small opening into the lumen at one side. The mesentery below was black. There was edema of the wall and thrombosis of both large and small vessels. Apparently the segment which had appeared viable at the previous operation had become necrotic at one point but fortunately had been walled off by adhesions.

Recovery from this operation was uneventful. Since discharge from the hospital there has been no further trouble.

Note.—This sequence of obstructions represents the danger in returning a badly damaged bowel to the abdominal cavity. According to our present criteria, there was every reason to suppose that this segment would recover. Apparently, however, one portion of the gut had progressive thrombosis of its vessels with necrosis, perforation and walling off by adhesions of the involved area. The question may be raised as to whether a badly damaged segment is not always a potential danger either for perforation or as a focus for future obstruc-

HIRSCHSPRUNG'S DISEASE; INDICATIONS FOR AND RESULTS OBTAINED BY SYMPATHECTOMY

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THE term Hirschsprung's disease² is synonymous with congenital megacolon of neurogenic origin and is used to distinguish this disease from acquired megacolon arising from chronic obstructing lesions. In the former, the megacolon results from neuromuscular dysfunction; whereas, in the latter, it develops from mechanical obstruction. The correction of Hirschsprung's disease therefore becomes a neurosurgical problem, a problem of reestablishing normal peristaltic movements and regulated periods of defecation.

ETIOLOGY

Hirschsprung's disease is presumed to be of neurogenic origin, in which the mechanism for filling the intestine or for retaining intestinal content overbalances the emptying mechanism; this accounts for the retention of feces in the dilated and hypertrophied sigmoid and colon (Fig. 1). The patients are usually children or young people. It is apparent that the inhibitory muscular responses to the colon, and the contracting stimuli to the internal sphincter of the anus from the sympathetic outflow are more powerful than the motor responses to the musculature of the colon and the inhibitory responses to the internal sphincter of the anus, which come from the parasympathetic nerve supply. It is difficult to explain this dysfunction of the neuromuscular mechanism, unless the subject is constitutionally inferior, and the general nervous system calls for hyperactivity of the sympathetic nervous system to meet the demands of the body in endocrine secretions, which in turn develop excessive stimuli in the sympathetic fibers innervating the colon and internal sphincter of the rectum. Defective parasympathetic innervation might produce a similar effect, since the emptying stimuli would be less than the filling and retaining stimuli.

Acquired megacolon results from chronic obstruction, which is seen to result from elongation of the mesentery, torsion of the segment or multiplication of the intestinal loops. Anatomic factors, such as faulty valves, spasm of the musculature above the rectum, and obstructing bands, are likewise responsible for megacolon. Infective processes in-

changes in diet, atropine, ultraviolet light, paregoric, opium, bismuth. For one month she required very careful nursing, but at the end of that time her intestinal tract began to behave normally. She was discharged to a convalescent hospital where she slowly recovered. After six months in this institution, she returned to her home. In December, 1933, she had gained 24 pounds and felt normal in every way. Her bowels were regular. There was no further pain in the abdomen. She has remained in excellent health since that time without any further complications. She has taken her place in the community for three years and has not lost any time because of illness.

This case shows how many different lines of attack a surgeon must call upon in order to get his results in some complicated cases. It also illustrates the value of courage and optimism on the part of both patient and attendants.

CASE 6.—J. B., No. 18198, a man, forty-two years of age, was admitted to the Rochester Municipal Hospital on September 20, 1928. He was a very sick man with a generalized peritonitis from a ruptured appendix of several days' duration. The appendix was removed, no drainage was instituted. Paralytic ileus developed, and a jejunostomy was performed under local anesthesia. After one week of continued paralytic ileus, the jejunostomy began to function. One week later, a pelvic abscess was drained in the right side. Three weeks later because of failure to improve, exploration of the pelvis was done. Many adhesions were present, and some definite points of obstruction were freed. This resulted in normal functioning of the bowel. Then the enterostomy began to be troublesome; much fluid was lost through this opening. The abdominal wall became excoriated and required constant attention. On November 12, 1928, the enterostomy opening was resected and an end-to-end anastomosis was done. His recovery was rapid following this. He was discharged on December 10, 1928. He was readmitted for an acute intestinal obstruction with volvulus on December 19, 1928. *This had followed eating a large meal at home.* After release of this obstruction, he made a good recovery and was discharged on January 12, 1929. He had no further trouble from obstruction. A ventral hernia was repaired in June, 1931. Since that time he has been in the dispensary for many minor complaints. He has had no further intestinal involvement to date.

Enterostomy for paralytic ileus is not a good procedure. The bowel will not drain well until it recovers its tone. In the presence of an acute peritonitis, enterostomy is often a positive danger. Wangensteen suction drainage will usually do everything that an enterostomy can. The patient is not subjected to a major risk by this latter type of therapy.

and occasionally the entire colon is enlarged without the presence of any obstructing lesion, while the acquired type of megacolon is always associated with a demonstrable mechanical obstruction. The acquired type of megacolon results from chronic obstruction and not from acute obstruction, which produces dilatation of the colon with thinning of the tunics.

Thickening of the tunics, particularly the muscular layer, appears to be a compensatory response to overcome the obstruction, whether it is neurogenic or mechanical (Fig. 2). Dilatation is but another com-

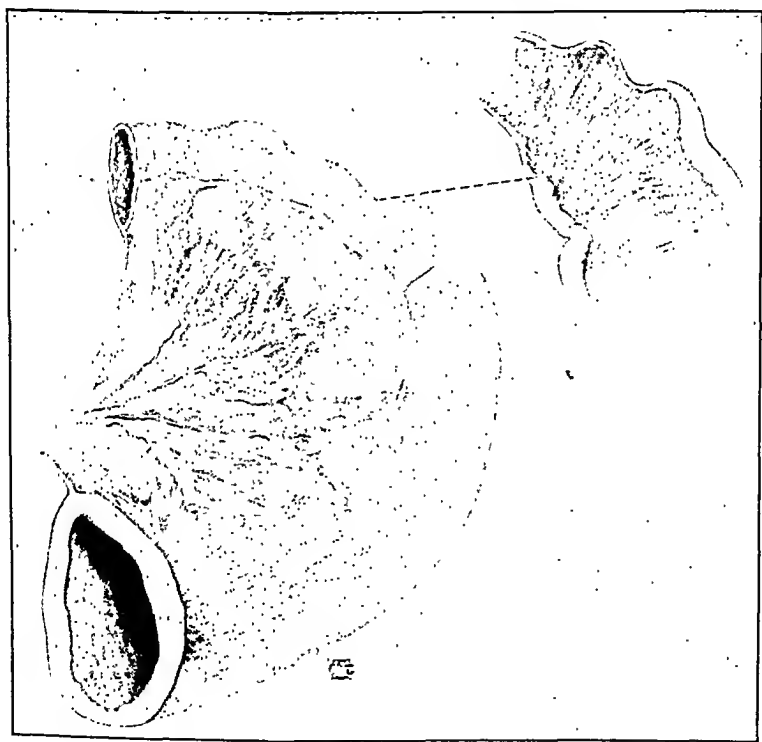


Fig. 2.—Showing the absence of mechanical factors limiting the proximal dilatations of the transverse colon.

pensatory factor in providing for the retained feces and accumulation of gas. Histologically, the circular and longitudinal muscular fibers are seen to be hypertrophied, which explains the elongation of the sigmoid mesentery. The peritoneum covering the enlarged bowel has lost its luster and often reveals scarred striae running parallel with the colon, causing it to appear as if it were in a fibrous bag. Lymphatic channels may be seen to run underneath this peritoneal covering and are often associated with increase in number and enlargement of lymph nodes. The submucosa and the mucosal layers are likewise hypertrophied and may be associated with ulcerated areas.

volving the intestinal musculature and slowly growing carcinomas of the rectosigmoid may also give rise to chronic obstruction and produce megacolon.

PATHOLOGY

The pathologic changes of megacolon of neurogenic origin, and of obstructive origin, are very similar. Hirschsprung, in 1886, in describ-



Fig. 1.—Drawing made at the time of operation showing megacolon due to Hirschsprung's disease. Note the portion of bowel involved and the absence of mechanical obstruction.

ing the condition found in children, referred to the disease as a congenital, high-grade dilatation of the colon with thickening of all tunics, especially the tunica muscularis, with retention of large quantities of fecal matter. The congenital type differs from the acquired type in that the former type is present at birth, whereas the latter develops subsequently. In the congenital type of megacolon the left half of the colon

mesenteric ganglion; whereas, the motor nerve cells for the internal anal sphincter and the internal vesical sphincter are in the inferior mesenteric ganglion.^{10, 11, 15} The inhibitory nerves to the internal anal sphincter and to the internal vesical sphincter, according to Elliott,^{10, 11} travel through the pelvic nerve as a part of the sacral outflow. The motor nerves to the musculature of the large intestine, according to Bayliss and Starling,^{5, 6} and also according to Langley and Anderson, are likewise a part of the sacral outflow and travel through the pelvic nerve. Elliott⁹ has confirmed this by determining that injection of epinephrine does not cause contraction of any part of the large intestine, with the exception of the internal anal sphincter. Inhibition of the musculature of the large intestine is mediated through inhibitory nerves, the cells of which are in the inferior mesenteric ganglion;¹⁰ stimulation of the lumbar splanchnic nerves, or of the hypogastric nerves, causes relaxation of the musculature of the colon.

Learmonth and Markowitz^{18, 19} have shown that electric stimulation of the presacral nerve and of the inferior mesenteric nerve of the dog leads to dilatation of the colon and to contraction of the internal sphincter of the anus. They also demonstrated that section of these nerves increased the activity of the lower portion of the colon.

To clarify further the anatomy involved, it probably would be well to review the anatomic arrangement of the sympathetic fibers which produce inhibition of the musculature of the lower portion of the colon and constriction of the internal sphincter of the anus. The post-ganglionic sympathetic fibers which carry these impulses originate in the intermesenteric plexuses. This network of nerves descends on the anterolateral aspect of the abdominal aorta, from the level of origin of the superior mesenteric artery downward. On each side there are two or three large trunks, which arise from: (1) the semilunar ganglion and the celiac plexus; (2) an anastomotic loop which crosses the aorta transversely, below the origin of the superior mesenteric artery; and (3) the aorticorenal ganglion, or the renal periarterial plexuses.

The intermesenteric plexus is joined on each side by branches from the first and second lumbar ganglia. The branches contain myelinated fibers; those on the right side pass between the vena cava and the aorta to reach the anterior side of the aorta. The fibers which form the intermesenteric plexuses are thus derived from two sources: their original fibers spring from that part of the abdominal sympathetic system which is connected with the thoracic splanchnic nerves; whereas, the branches which the plexus receives as it descends along the aorta spring from the lumbar ganglia or trunks.

According to Elant,⁸ the triangular mass, the superior hypogastric plexus, receives a series of secondary connections from other regions:

SYMPTOMS

The symptoms arising from Hirschsprung's disease may vary from obstipation to complete obstruction. In the milder cases the results may be only abdominal distention and infrequent defecation; whereas, in the more exaggerated forms, marked abdominal distention with flaring of the ribs, respiratory and cardiac embarrassment, and toxic symptoms from retained feces, with absence of spontaneous defecation, may occur. The toxic symptoms result in general malaise, lack of appetite, emaciation, and irritability with a septic type of temperature.

MEDICAL CARE

In the milder cases, the condition often can be controlled by a medical regimen which consists of administration of mild cathartics, such as milk of magnesia, mineral oil by mouth and by retention enema, and the occasional use of glycerin suppositories. In the more severe cases, the diet may need to be changed from bulky foods to a diet containing nonresidue foods, with the substitution of broth and of preparations of milk and sugar to maintain the caloric value. Medication with such substances as acetylcholine, pituitrin, eserine (physostigmine), and drastic purgatives are often used. The distended colon may require emptying by mechanical means after thorough dilatation of the external sphincter. If oil and soapsuds enemas are ineffective, enemas containing hydrogen peroxide may become necessary to break down fecal impactions. Hospitalization is necessary to establish a routine, and it is only when these regulated measures, carried out at home, fail, that surgical intervention is considered.

Diathermy when applied to the abdomen has produced an increase in peristaltic movement in evacuation of fecal content, but unfortunately, the effects are temporary and the results do not continue when diathermy is discontinued.

Surgical procedures such as appendicostomy, colostomy, enterostomy, and partial colectomy were formerly employed in severe cases; but since so many of these procedures failed to give relief and were attended with a surgical mortality of 25 per cent or more, the newer method of operation on the sympathetic nerves of the pelvis has replaced the major operations.

ANATOMY AND PHYSIOLOGY OF THE RECTUM AND BLADDER

Gaskell¹² has pointed out that there are three sphincter muscles which terminate the different regions of the primitive intestine: (1) the ileocolic sphincter at the end of the small intestine; (2) the internal anal sphincter at the end of the coprodeum; and (3) the internal vesical sphincter and the urethral muscles at the end of the urodeum. The motor nerve cells for the ileocolic sphincter are situated in the superior

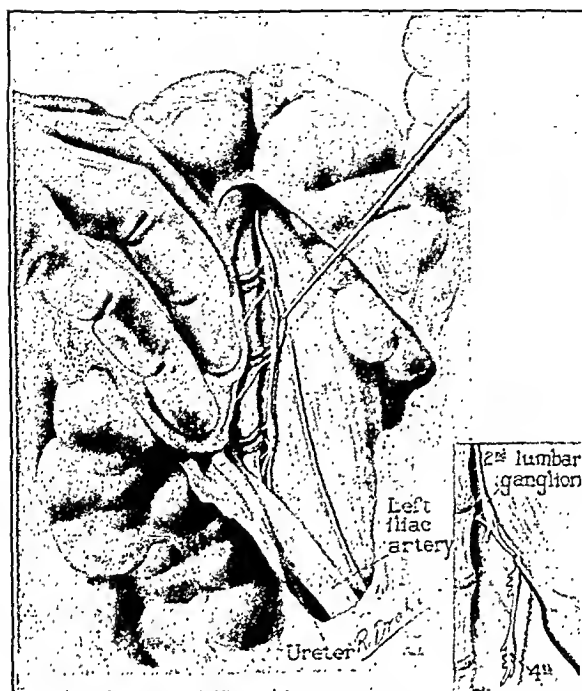


Fig. 3.—Exposure and resection of the left lumbar sympathetic trunk with the second, third, and fourth lumbar ganglia.

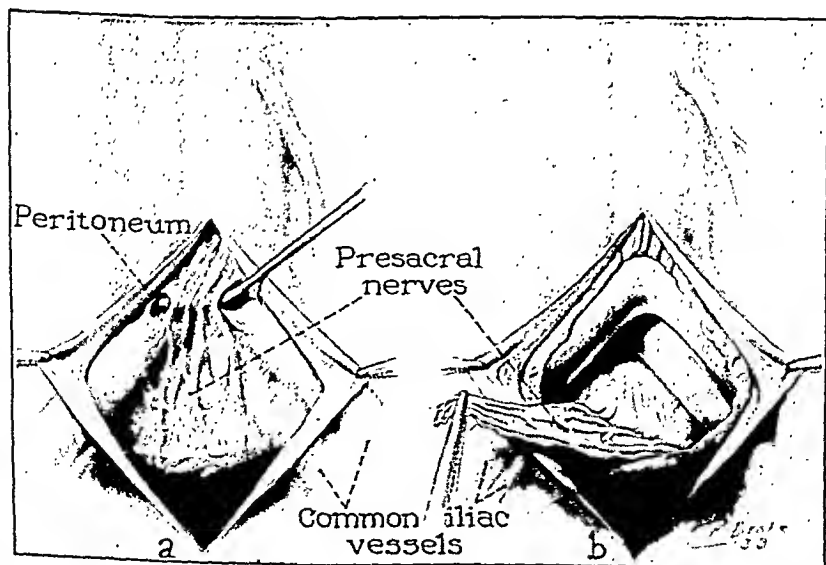


Fig. 4.—a, Elevation of presacral nerves as they cross the bifurcation of abdominal aorta; b, illustrating the method of presacral nerve resection.

first, from the inferior mesenteric plexus which lies within the pelvic mesocolon at its left; and second, from the last ganglion of the lumbar chain on each side.

Anatomists have held different opinions concerning the extent to which the lumbar fibers mingle with those of the intermesenteric plexus proper. According to Delmas, Laux, and others, the mesially directed lumbar communicating branches, constituting the pelvic splanchnic nerves, remain distinct in the outer part of the plexus and ultimately form the lateral roots of the presacral nerve of Latarjet (superior hypogastric plexus of Hovelacque). On the other hand, Hovelacque held that these lumbar communicating branches actually contributed to the intermesenteric plexus. The point is one of great significance. If the former view were correct, lumbar ramisectomy and ganglionectomy would affect only that portion of the bowel that is innervated through the presacral nerve, the lower part of the rectum, and the internal sphincter of the anus; if the latter arrangement were true, it would affect, but only partly, the descending and sigmoid portions of the colon, as well as the rectum and the internal sphincter of the anus.

Immediately below the level of origin of the inferior mesenteric artery, a large branch leaves the intermesenteric plexus of each side, and passes inward, on the aorta, to reach the inferior mesenteric artery about 1.5 cm. from its origin. Finally, these two trunks unite and give rise to three or four branches which course along the lateral borders of the vessel, communicating at intervals with each other. From these nerves subsidiary trunks arise at levels of the main divisions of the artery. Soon, however, they abandon the vessels and anastomose with one another in avascular parts of the mesosigmoid. From this network the final nerves of distribution are derived; these slender filaments cross the juxtaecolic vascular arcades and enter the wall of the bowel between the terminal branches of the vessels, and account for part of the innervation of the colon and internal sphincter; the remaining sympathetic innervation is composed of fibers which continue downward into the pelvis from the intermesenteric plexus and from the lumbar trunks below the second lumbar ganglion, to make up the superior hypogastric plexus before entering the superior hypogastric ganglion where the sympathetic nerves mingle with parasympathetic fibers, and finally is distributed to the musculature of the lower part of the colon, sigmoid, and internal sphincter of the rectum.

SURGICAL CONSIDERATIONS

In comparing the results in treating the various degrees of megacolon by the various types of sympathectomy, it becomes apparent that the more advanced the disease, the more complete the resection of sympathetic fibers must be in order to produce the results desired. The operation of Wade,^{22, 23} removal of the first and second lumbar ganglia on the

the patient obtained one to two spontaneous daily bowel movements following the operation. It also encouraged us to employ the same procedure for two female patients who complained of obstinate constipation, attributable to an enlarged atonic colon, with equally good results.

Therefore, it would appear that extensive sympathectomy which includes the splanchnic nerves and first and second sympathetic ganglia on both sides is the operation of choice when megacolon is of neurogenic origin and involves the whole colon. The more limited operations may be employed when the disease is mild in degree and involves only the sigmoid and lower portion of the descending colon.

Surgical Indications and Preoperative Preparation.—As previously stated, surgical intervention is not instituted in the mild cases of Hirschsprung's disease in which medical treatment is adequate, but if it be-

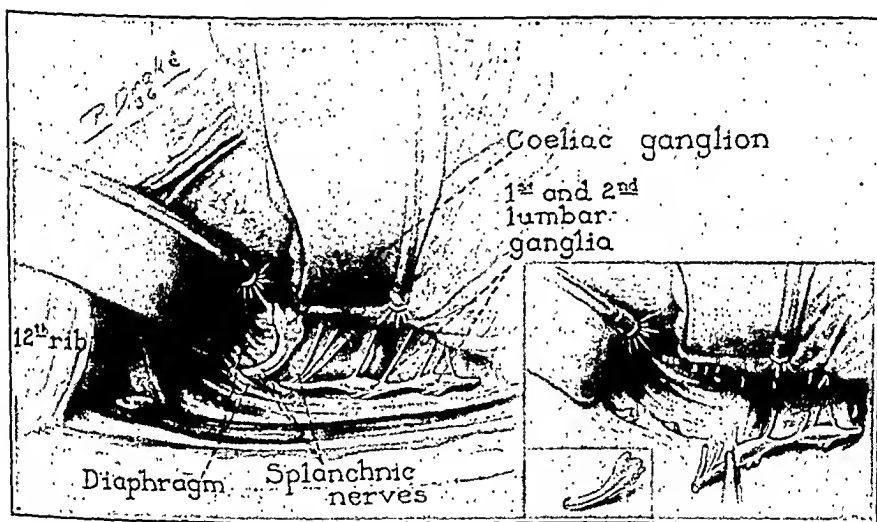


Fig. 5.—Exposure and resection of splanchnic nerves with a portion of the celiac ganglion and removal of the first and second lumbar ganglia.

comes necessary for the patient to return to the hospital more than two or three times for emptying of the colon and the employment of a still more rigid regimen, sympathectomy is indicated. I have operated on a child aged five and a half months, but have observed that the operation is more easily accomplished if the child is one or more years of age. The administration of acetylcholine, which inhibits the activity of the sympathetic nervous system, has served as a preoperative test in selecting patients for sympathectomy.

Before operation is indicated, hospitalization is required and thorough evacuation of the filled colon is necessary, but although this process may require a week or two, the general nutrition of the patient should not be neglected. The colon may be emptied by the procedure employed in following out medical care, and nutrition should be maintained by

left, is sufficient in the moderately severe case. Bilateral sympathetic ganglionectomy and trunk resection performed by Judd and the author,¹⁴ which includes removal of the second, third, and fourth lumbar ganglia with the intervening trunk, has been found to be still more effective¹ in my experience than unilateral resection (Fig. 3). Resection of the inferior mesenteric nerves in conjunction with resection of the presacral nerve (Fig. 4), the operation of Rankin and Learmonth,^{20, 21} has been shown to be effective in the moderately advanced case, but has failed to give all that has been desired, as has bilateral lumbar trunk resection in the most advanced cases of Hirschsprung's disease.

This observation prompted me to increase the scope of the operation still further and it now includes resection of both lumbar trunks, including the second, third, and fourth lumbar ganglia, with wide resection of the superior hypogastric plexus, presacral nerve, situated on the promontory of the sacrum in the triangular space below the bifurcation of the abdominal aorta. This procedure is employed to include all of the sympathetic fibers from the lumbar chain, all of the intermesenteric fibers descending into the pelvis below the inferior mesenteric artery, and those fibers which rejoin the hypogastric plexus from the inferior mesenteric nerve in the mesocolon of the pelvis, thus leaving only a small group of fasciculi which have followed the inferior mesenteric artery and its branches to the lower part of the colon and internal sphincter of the anus.

Although this extensive lumbar, presacral, and inferior mesenteric sympathectomy is effective in relieving the symptoms of Hirschsprung's disease involving the sigmoid and descending colon, it has not been effective in relieving the symptoms when the ascending and right half of transverse colon have been involved, which suggests that inhibitory responses reach the ascending and transverse colon through nerves which accompany the superior mesenteric artery.

This opinion was further substantiated by experiences obtained in resecting the splanchnic nerves and removing the first and second sympathetic lumbar ganglia and intervening trunk on both sides in the treatment of essential hypertension, since these patients occasionally complained of increased intestinal peristalsis following the completing of the operation on both sides. The increased peristalsis resulted in increased daily bowel movements. This frequency soon adjusted itself to one or two daily bowel movements, unless the patient ate generous helpings of fruit such as prunes, figs, or raisins when diarrhea might follow. This increased intestinal activity encouraged me to employ bilateral resection of the splanchnic nerves in conjunction with bilateral removal of the first and second lumbar ganglia in a case of Hirschsprung's disease in which the entire colon of a youth aged nineteen years was involved (Fig. 5). The results were extremely gratifying in that

forates the psoas muscle), the psoas muscle, the lumbar vertebrae, the lymph nodes, and the lumbar sympathetic ganglia, trunk, and rami communicantes which lie on the lumbar vertebrae, just mesial to the psoas muscle. The ureter on the left side is more easily retracted mesially than laterally. With a moist sponge it is held gently, together with the colonic mesentery,¹ the upper end of the sigmoid, and the lower end of the descending colon, in position in the median line. The abdominal aorta is elevated and is retracted mesially by traction with a finger on the gauze sponge. This is held by an assistant. The sympathetic ganglia, trunks, and rami are then dissected free by a wet cotton ball dissector held in thumb forceps. It is well to begin at one or the other end of the lumbar sympathetic chain. On the left side, it is preferable to expose the fourth lumbar ganglion at the brim of the pelvis and to divide the sympathetic trunk below it. All of the rami, including those to the spinal nerves, the hypogastric plexuses, and the aortic plexuses, are then divided. The dissection is then carried upward to include the fourth, third, and second lumbar sympathetic ganglia. Undue traction should not be exerted on any of the tissues handled, especially on the mesentery leading to the sigmoid and other portion of the colon, so as to avoid the possibility of rupture or thrombosis of arteries or branches of arteries which supply the large bowel.

The approach to the lumbar sympathetic ganglia on the right is similar to that on the left, except that the peritoneal incision is made just lateral to the right lateral border of the abdominal vena cava and is carried downward over the right common iliac vein into the true pelvis, upward and mesially along the root of the mesentery of the small intestine, partly across the vena cava for a distance of 15 cm. from the brim of the pelvis, and downward into the pelvis for a distance of 5 to 7 cm. The cecum, small intestine, and ureter are retracted outward and upward. The vena cava is retracted mesially, and the common iliac vein, downward and mesially. In the posterior wall of the peritoneum, just above the brim of the pelvis on the right side, several small veins may be encountered which can be divided and ligated. Further exposure, and removal of lumbar sympathetic ganglia and division of all of the rami and the sympathetic trunk are similar to the procedures employed on the left side. However, the fourth lumbar sympathetic ganglion on the right side usually lies underneath the intravertebral vein and not superficial to it, as it does on the left side.

Presacral Resection With Removal of Second, Third, and Fourth Lumbar Ganglia.—When this procedure is combined with bilateral lumbar trunk resection, the superior hypogastric plexus is readily exposed by extending the lower end of the right peritoneal incision diagonally into the pelvis across the promontory of the sacrum. If the surgeon chooses, the plexus can be equally as well exposed through a midperitoneal incision

means of a high calorie, nonresidue diet with the addition of vitaminized oils. Complete physical examination and laboratory tests are essential to determine if operation can be performed. It is not always wise to employ barium enemas to determine the size of the colon, for often a week or more is required to remove thoroughly all of the barium, which may delay the preoperative period. Roentgenograms made after inflation of the colon usually give the desired information. It is not wise to prolong preoperative preparation unduly for fear of impairing the general nutrition by eagerness to keep the colon empty on a nonresidue diet, since some patients object to taking sufficient food in the prescribed diet to maintain the proper intake of calories.

Technic for Removal of Lumbar Sympathetic Ganglia.—The patient is placed on the operating table in the laparotomy position. The most suitable anesthetic is ethylene and ether or spinal anesthesia supplemented with ethylene.

The incision⁴ is made from the symphysis pubis to a point 5 to 7 cm. above the umbilicus, between the rectus abdominis muscles and to one side of the umbilicus. The sheath of the rectus muscle subsequently is opened on each side below the umbilicus and on the left side above the umbilicus, facilitating closure along anatomic lines. If the abdomen is extremely flaccid, it may be advisable to make an overlapping closure (C. H. Mayo type) in the external leaves of the fascia of the rectus abdominis muscle. Before the peritoneum is opened, the patient is lowered from the horizontal position to the Trendelenburg position, thus insuring better exposure of the lumbar sympathetic ganglia. Although general exploration may reveal other abdominal lesions, they are not disturbed at this time, since it is desired to avoid the additional risk of contamination. The intestines are packed upward, as they are when hysterectomy is performed. It is immaterial whether the ganglia are approached first on the right or on the left side. Usually, the ganglia of the right side are more difficult to approach because the intervertebral veins run across the sympathetic trunk. To elevate the inferior vena cava is more difficult than to elevate the abdominal aorta and the common iliac artery on the left.

When exposing the left lumbar sympathetic chain, it is necessary to loosen and elevate the sigmoid and the lower portion of the descending colon. This is done by incising the peritoneum superior and just lateral to the anterolateral border of the upper portion of the sigmoid and the attachment of the lower portion of the descending colon. When the line of cleavage is once started, the large bowel can be elevated readily and can be retracted, with the posterior wall of the peritoneum, beyond the median line. This exposes the ureter (as it courses over the bifurcation of the common iliac artery), the left common iliac artery and vein, the lower end of the abdominal aorta, the genitoernal nerve (which per-

structures, periosteum of the twelfth rib, intercostal vessels, and nerves, which affords a much better exposure of the splanchnic nerves and lumbar ganglia. A wide, illuminated retractor is then introduced into the wound at right angles to the spinal column. It is used to displace the liver forward, then downward, and at the same time to lift the capsule about the perinephric fat with its contents (the kidney and suprarenal gland) in a similar direction. Since the patient is placed on his side with elevation of the opposite loin with the kidney rest, it is not difficult to displace these structures forward and downward, care always being taken to avoid sudden or jerking movements. The tissues are further protected by introduction of a salt laparotomy sponge, with the retractor placed on the sponge to assure against trauma to the underlying tissues. Gentle dissection with moist cotton-ball sponges reveals, first, the splanchnic trunk composed of major and minor and lesser splanchnic nerves, which are about 2 cm. in length. Dissection is carried mesially until the lateral border of the celiac ganglion is exposed. The resection includes a few millimeters of the ganglion with the splanchnic nerves. The first and second lumbar sympathetic ganglia are exposed in turn and are removed in conjunction with the intervening trunk in order to interrupt fibers that pass through the lower end of the thoracolumbar sympathetic trunk.

After hemostasis has been thoroughly controlled, the liver and perinephric fat capsule are allowed to fall into place.

The kidney rest is then lowered, the muscular fascial planes are approximated with continuous and interrupted sutures of No. 1 chromic catgut. The subarcuate tissue is approximated with continuous No. 1 plain catgut. The skin is closed with a continuous locking stitch of dermal or silk sutures. No drainage is employed.

The opposite splanchnic nerve and the first and second lumbar ganglia are resected in about ten days following the first operation.

Postoperative Care.—At the conclusion of the operation, while the patient is anesthetized, the rectum is thoroughly dilated. In the moderately severe cases, spontaneous defecation occurs on the following day and continues daily. In the severe cases, soapsuds enemas, retention oil enemas, and mild cathartics may be required. Occasionally, acetylcholine and eserine (physostigmine) have been required during the first few days after operation. As convalescence continues, the abdominal distention subsides, with reduction in the size of the colon. In roentgen examination of these patients months after the operation, the peristaltic movements of the diseased colon are seen to increase in frequency and force, and again present the normal haustra. The colon probably never returns to normal size, but does empty regularly once or twice a day. The splanchnic operation just described has produced more active peristalsis than the other operations and actually has produced diarrhea during the first

extending downward from the bifurcation of the abdominal aorta into the pelvis over the sacral promontory for a distance of 5 cm. On elevating the peritoneal flaps a triangular mass of nerve bundles and fibrous tissue is exposed between the peritoneum in front and the fifth lumbar vertebra and sacrum behind. This mass is known as the superior hypogastric plexus of Hovelacque and its constituents are referred to as the presacral nerves. These sympathetic nerves are a continuation of the intermesenteric plexus and the postganglionic fibers from the first and second lumbar ganglia. The hypogastric plexus (Elaat) also receives additional fibers from the lower end of the lumbar chains and from the inferior mesenteric nerves in the region of the pelvic mesocolon. This mass of nerve tissue is removed in one piece. The dissection is begun at the apex of the triangle which has its point at the bifurcation of the aorta. The nerve fibers are gently elevated from the aorta, common iliac arteries, and left iliac vein, are incised, and are held by a forceps as a retractor. The dissection is directed downward into the pelvis for 5 cm. and laterally to the base of the triangular mass, which usually measures 3 to 4 cm., when all communications are severed, freeing a triangular mass composed of individual nerves, groups of nerves, and dense fibrous bands. The coccygeal artery in the median line usually needs to be included to effect complete removal of the superior hypogastric plexus. The peritoneal incisions are closed with a running continuous suture of catgut.

Splanchnic Resection With Removal of the First and Second Lumbar Ganglia.—The incision³ employed and the position of the patient on the operating table for extensive sympathectomy are similar to those employed for exploration of the kidney, except that the incision is made to follow anatomic lines. The line of the incision is similar to that of a hockey stick, with the staff portion placed just lateral to the rectus spinous muscles and the club portion extending obliquely downward and forward over Petit's triangle just above the crest of the ilium. At the upper portion of the wound, after the skin and subareolar tissue have been incised, the oblique fibers of the latissimus dorsi muscle are incised, thus exposing the twelfth rib. As the incision is extended downward along the course of the skin incision, the common aponeurosis of the external and internal oblique muscles, and of the transversalis muscle where it fuses with the lateral reflection of the lumbar fascia, is incised until the fusion extends into Petit's triangle, exposing the capsule surrounding the perinephric fat.

The next step in the operation consists of performing subperiosteal resection of the twelfth rib, care being taken not to injure the pleura; the finger is then introduced into the subdiaphragmatic space above the perinephric fat in order to dissect free the subcostal ligament of the twelfth rib, since division of this will allow upward retraction of the

on for atonic dilated colon. One patient with Hirschsprung's disease and two with atonic dilated colons underwent extensive splanchnic and lumbar resection. The rest underwent one of the limited sympathectomies. The ages of the patients with Hirschsprung's disease at the time of the operation varied from five and a half months to nineteen years. Only two patients were nineteen years of age. Three patients were eight years of age, and the remainder were



Fig. 7.—Same patient as shown in Fig. 6, four months after bilateral lumbar sympathectomy.

six years of age or younger, two being less than one year of age. In the younger group the disease involved only a limited portion of the colon, with the exception of one patient (G. V.) whose entire colon was involved. The combined operation of bilateral lumbar sympathectomy, with removal of the second, third, and fourth lumbar ganglia and resection of the presacral nerves, failed to give relief in this case. Consequently, this patient was subjected to colectomy, from which he obtained a satisfactory result. The children whose descending colon and sigmoid

ten days after operation, which makes me believe that it is more effective and is indicated in the severe types of Hirschsprung's disease. The hospital diet is similar to that given to children with similar laparotomy wounds. The average stay in hospital is twenty-eight days, ten of which are spent in bed. On dismissal the patient or the parents are instructed gradually to discontinue the use of cathartics, soapsuds enemas, and finally the oil retention enemas as the patient establishes a regular habit

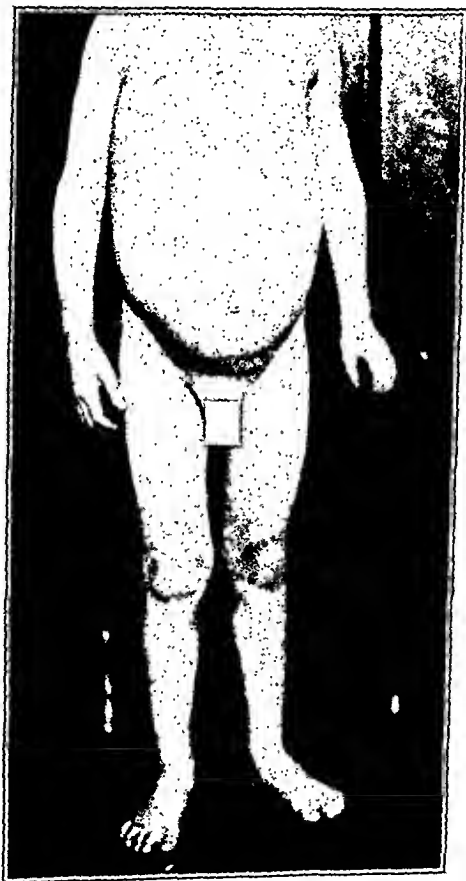


FIG. 6.—Anterior view, illustrating distention of the abdomen accompanied by eczema due to Hirschsprung's disease.

of defecation in the morning and evening. In less severe cases cathartics and enemas are discontinued immediately; whereas, in advanced cases from six weeks to six months may be required before daily spontaneous defecation takes place.

CLINICAL RESULTS

In reviewing the series of cases of megacolon in which patients were operated on at the Mayo Clinic, I find that twenty-two patients were operated on for Hirschsprung's disease and eight patients were operated

plain death other than that the patient was subject to asthmatic attacks which we attempted to control by the administration of epinephrine. A case has been reported in which the patient died three years after an operation which had been followed by excellent results. Death occurred suddenly without explanation; unfortunately, a necropsy was not obtained.

There were eight cases of megacolon of the atonic type, in six of which the patients were submitted to the limited operation which included either bilateral removal of the lower lumbar sympathetic ganglia or resection of the inferior mesenteric nerves and of the presacral nerves, or a combination of two or all three of these operations. The results were unsatisfactory. There were no cures in this group, but in all instances the need for extensive purgation was reduced so that milder cathartics and enemas would initiate evacuation of the bowel. Two patients were submitted to extensive sympathectomy which included bilateral resection of the splanchnic nerves combined with removal of the first and second lumbar ganglia. The postoperative results in both of these cases were excellent, and they have continued to be so to date (a period of nine months). This postoperative period, however, is too short to draw final conclusions. There were no deaths in this group of eight cases.

Sequelae.—No immediate untoward results were observed following the lumbar, intermesenteric, or presacral sympathectomies. Vasodilatation followed in the arterioles of the skin covering the feet, legs and other organs robbed of their sympathetic nerve supply, since the vasomotor fibers are intermingled with the sympathetic motor fibers and naturally are included when the latter are resected. There is a loss of the sweating function over the same area. In women, the sexual organs were not disturbed by sympathetic resection, since I have observed the postoperative effects of resection of presacral nerves in many adult females. Extirpation of the presacral nerve in men does paralyze the mechanism of ejaculation of seminal and prostatic fluid, but does not disturb the libido and potentia. Resection of the presacral nerve does weaken the urinary filling mechanism by decreasing the inhibitory stimuli to the muscles of the bladder and the contracting stimuli of the internal vesical sphincter, but does not produce urinary frequency. The presacral operation has been employed for the treatment of cord bladder. The sequelae of splanchnic resection and removal of upper sympathetic ganglia are similar to the effects obtained by combined bilateral lower lumbar and presacral sympathectomy, with the exception that the vasodilating effects produce increased skin temperatures over a larger area from a level midway between the umbilicus and the symphysis downward over the lower part of the abdomen, including the thighs, legs, and feet. There is loss of the sweating function over the same

were involved obtained excellent results; whereas, those whose disease had extended to include the left half of the transverse colon obtained results from good to fair.

In one case in this group a very limited operation was performed. The patient (H. J.) had involvement of the sigmoid, descending colon and left half of the transverse colon. The operation performed was a left sympathetic lumbar ganglionectomy, the operation of Wade. Immediately following this limited operation the results were satisfactory, but, as time progressed, the patient's symptoms returned and on reexamination I learned that the disease had extended to involve the entire colon. The original operation was performed ten years ago, and in light of the results obtained by bilateral resection of the splanchnic nerves, with inclusion of the upper two lumbar ganglia, it would appear that we are justified in operating again on this child, who is now eleven years of age.

The two patients who were nineteen years of age had involvement of the entire colon. One was submitted to bilateral lumbar sympathectomy combined with resection of the presacral nerves, and the results obtained were only moderately effective. The other was submitted to extensive splanchnic and upper lumbar sympathectomy. The results to date in this case are very satisfactory and much more effective than those obtained in the case of the patient who was submitted to the limited operation which included the lower lumbar and presacral nerves. When I refer to an excellent result, I mean to imply that the patient is able to have spontaneous bowel movements without assistance from cathartics or enemas. A good result implies regular bowel movements with the occasional aid of a mild cathartic, and a fair result implies that the bowel movements are obtained only by daily enemas and mild cathartics.

In most instances the toxic symptoms were relieved. The patient's appetite improved and his languor disappeared. In the less serious cases the distention was relieved and the potlike belly receded, but in those cases in which the entire colon was involved, patients still presented a full belly and peristaltic waves could be detected when the colon became filled with gas (Figs. 6 and 7). These peristaltic waves were usually more active following operation, and postoperative roentgenograms demonstrated definite haustra, while, preoperatively, the roentgenograms presented the characteristic saclike colon. Although the various sympathectomies relieve the symptoms, it is unreasonable to expect the thickened wall of the bowel to resume its normal texture, and consequently most of these patients have a fuller abdomen than normal individuals.

Two patients with Hirschsprung's disease died postoperatively. One died on the operating table as a result of postural influence, since these patients are operated on in the Trendelenburg position. The other died on the day following operation without any pathologic evidence to ex-

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area of skin. The potentia and libido are not disturbed in either sex. If there is any change they are both increased, but the ejaculatory powers of the male are lost. This loss of ejaculatory power of prostatic and seminal fluid invariably sterilizes the male, a sequela that adult males should be informed of and which the parents of young males should likewise know.

SUMMARY

In comparing the results reported in literature obtained by operations on the colon with those obtained by operations on the sympathetic nerves, I am convinced that the results of the latter procedures are superior to those formerly obtained by operation on the colon. The mortality is definitely less, and the period of hospitalization is shortened by months.

In selecting suitable cases for operation, typical cases of Hirschsprung's disease should be chosen, in which the response to medical treatment is inadequate. Operation should be performed early in the course of the disease.

On selecting the type of sympathectomy, the degree of the disease should definitely be evaluated and a procedure planned to include sufficient sympathetic fibers to balance the neuromuscular mechanism of filling and emptying of the colon.

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Surgical Society and the Philadelphia Academy of Surgery who was successfully handled by a jejunostomy for nine months, followed by a posterior gastrojejunostomy.

At the Children's Hospital in Boston, since 1932, there have been an additional twenty-eight cases of congenital duodenal obstruction. There have undoubtedly been other cases, reported or unreported, but these forty-two cases in five years are sufficient to show that this subject is receiving much more attention than it was ten years ago and that the efforts made in treatment are meeting with greater success.

EMBRYOLOGY

The various theories for these anomalies have been discussed in previous papers; suffice it to comment that the intrinsic obstructions are probably due to an arrest in development during the transition which the bowel goes through from a solid cord to a hollow tube, and that this arrest takes place prior to the twelfth week of fetal life. The extrinsic obstructions are likewise due to arrest in development in the normal return of the midgut from the umbilical cord and in its normal rotation.

SYMPTOMS AND SIGNS

The one symptom which is constantly present in these patients with congenital obstruction of the duodenum, regardless of the type, is vomiting. It is worth while to emphasize that vomiting in the newborn in the absence of cerebral injury or infection should suggest malformation in the alimentary tract. In the cases of atresia, the vomiting starts soon after birth or after the first feeding and contains the food ingested plus, in most instances, bile. In the cases of intrinsic stenosis, the vomiting may not occur until considerably later and may be intermittent in character. In cases of extrinsic obstruction due to faulty rotation, the vomiting may start soon after birth or may not occur for several weeks; and it is quite likely to occur in spells. In the intrinsic atresia cases, the physical examination may reveal a distended epigastrium with visible peristalsis or, if the infant be examined soon after he has vomited, the physical examination may be most striking by the absence of abnormal findings. In the intrinsic duodenal stenosis, one may occasionally see the peristalsis of the duodenum running obliquely downward from right to left. In both the intrinsic atresias and stenosis, one is sometimes struck by the prominence of the epigastrium and the sunken appearance of the hypogastrium. In the extrinsic obstructions due to arrested rotation or due to midgut volvulus, the symptoms may start soon after birth or not appear for months or even years. In no instance in our series have the children

CONGENITAL DUODENAL OBSTRUCTION

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IN 1932, I published a paper on "Congenital Obstruction of the Duodenum in Children,"¹ reporting ten cases, with seven cases successfully operated on. At that time in rather an exhaustive review of the literature, I found numerous cases reported, the first one being cited by Calder in 1752. Most of these articles were reports of autopsy findings. It was not until 1916 that Ernst² reported a recovery following an anterior duodenoenteroanastomosis in an eleven-day-old patient with duodenal atresia. Bolling, R. W.,³ reported a successful result from the operation of duodenojejunostomy in a nine-day-old infant, and Jewesbury and Page,⁴ and Rixford⁵ reported two cases of extrinsic duodenal obstruction successfully treated. Webb and Wangenstein⁶ also collected from the literature six cases successfully treated. Gastroenterostomy was the operation used in this group, but this operation had to be supplemented in one instance by a duodenojejunostomy. Prior to 1932, a moderately careful review of the literature revealed only ten cases of congenital duodenal obstruction that had been successfully operated upon. It seemed at that time that these cases should be more frequently recognized and more often treated successfully, and such has indeed proved to be true. Morton and Jones,⁷ in an article devoted to high obstruction in infants, report two cases of intrinsic duodenal obstruction, one of which was relieved by gastroenterostomy only to die twenty months later of pneumonia. The other was relieved by an operation which appears most logical, namely, making a longitudinal incision in the duodenum over the point of obstruction, destroying the septum by electrocautery, and suturing the incision transversely. They also report six cases of extrinsic duodenal obstruction relieved by the same type of operation described by me in 1932. They include three other cases, two of which were successfully operated upon, in which the obstruction was lower in the intestinal tract and are therefore not considered in the scope of this paper. Donovan⁸ has reported five cases of intrinsic obstruction relieved by anterior duodenojejunostomy, and Walter E. Lee recently showed a patient at the combined meeting of the Boston

tion was caused only by abnormal attachments of the colon or peritoneal folds, the symptoms were milder than in those patients in whom a midgut volvulus had taken place. In the latter situation, the midgut has gone through a twist of 360° or more, which not only almost com-

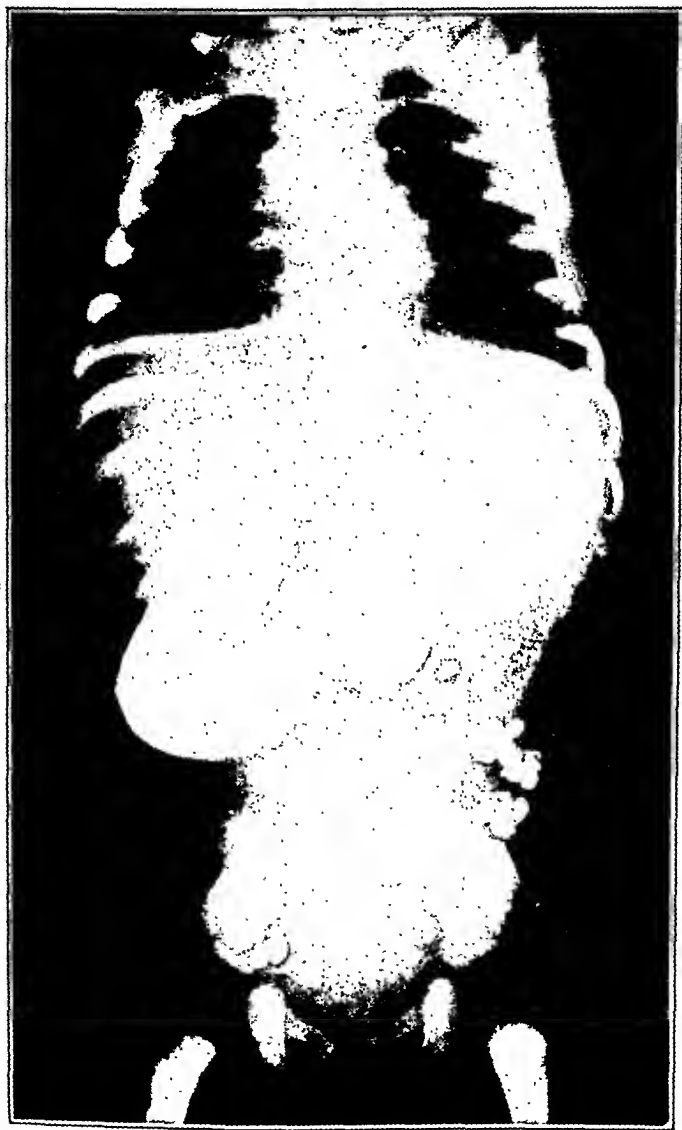


Fig. 2.—(No. 206499) A three-week-old infant with intermittent bilious vomiting since birth. Note dilated duodenum with barium retention. Diagnosis, duodenal obstruction due to malrotation of colon and midgut volvulus.

pletely obstructs the duodenum but also interferes with the circulation of the whole midgut, making an acute situation that demands quick relief. It is interesting to note that in our series when the midgut volvulus has been present, the rotation has taken place, in all but two

developed normally even though they may have been without symptoms suggesting partial obstruction. In the majority of cases, vomiting started soon after birth and persisted with remissions until such time as it became apparent that the infant was failing to progress or

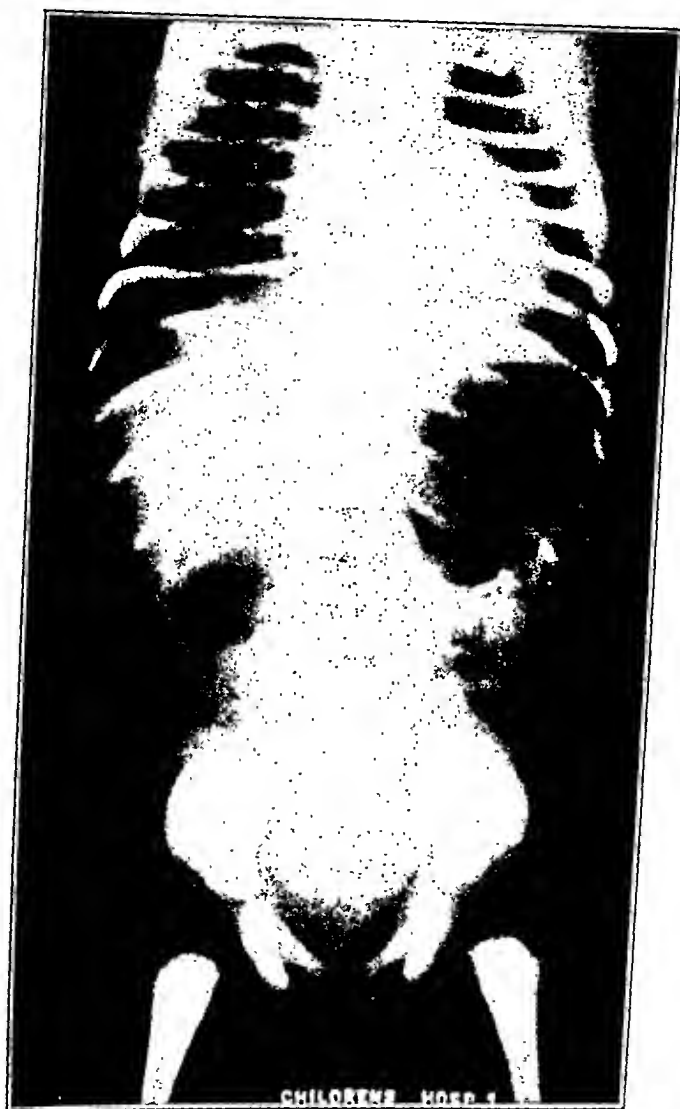


FIG. 1.—(No. 209112) A four-day-old infant with bilious vomiting since birth. Note how clearly outlined the dilated duodenum is without the use of contrast media. Note also small amount of air in lower intestine. Preoperative diagnosis, intrinsic stenosis; postoperative diagnosis, the same.

had become acutely and almost completely obstructed, the variation in the course of the child's progress apparently being dependent on the actual abnormality found. In those patients in whom the obstruc-

might cause obstruction either in the colon or jejunum or both. Retrocolic or posterior duodenojejunostomy has been successfully used six times in our clinic and this operation has been successfully used by others. If successful it should provide more adequate drainage for the duodenum and less chance of later obstruction. The drawbacks to this operation are the technical difficulties of its performance. The lack of mobility of the duodenum and the extreme thinness of its wall make an anastomosis in this situation quite difficult. I have recently lost a patient on whom I performed a duodenojejunostomy at the age of five days for intrinsic duodenal stenosis. This infant progressed extremely favorably up to the eighth day then developed peritonitis from which he died. From the postmortem examination it was felt that the peritonitis developed from the anastomosis although no gross leakage was evident. The duodenal wall was extremely thin, and it seemed quite possible that infection might have taken place about some of the stitches. From reports of postmortem examinations there appears to be a moderate amount of uniformity in the thickness of the velum causing these obstructions, and in its situation, between the second and third portions of the duodenum. It would seem that the operation mentioned earlier in this paper as reported by Morton, namely, destruction of the velum causing the obstruction and a plastic on the duodenum to enlarge the lumen, would restore much more normal conditions than any of the other operations so far used. The only possible disadvantage to this operation is the difficulty of approach.

Jejunostomy for feeding has been tried once in our clinic years ago, and it was unsuccessful. It would have no merit in a case with complete obstruction, and it has obvious disadvantages in any case. However, in view of the one successful case shown by Lee, it should not be entirely condemned. In our clinic, the operation of posterior duodenojejunostomy has been the most successful of the operations we have tried both as to immediate and late results. (Table I.)

TABLE I
OPERATIVE TREATMENT OF INTRINSIC OBSTRUCTION OF DUODENUM

OPERATION	NO. CASES	RECOVERIES	DEATHS
Duodenojejunostomy	10	6*	4
Posterior gastroenterostomy	2	1	1
Jejunostomy (for feeding)	1	0	1
Total	13	7	6

*One of these patients had had a posterior gastroenterostomy with subsequent recurrence of symptoms.

The treatment of congenital duodenal obstruction due to arrest in the normal rotation of the colon, whether or not complicated by mid-

instances, in a clockwise direction and that pressure takes place first on the duodenum, obstructing that portion of the intestine and preventing general abdominal or intestinal distention. In both the intrinsic and extrinsic type of obstruction, the x-ray is of great aid in confirming or refining the diagnosis. (Figs. 1 and 2.) On infants under a week of age, it is our practice to first take an x-ray plate without the administration of barium. This will frequently give all the information that is required. When the flat plate shows some air distributed through the intestine or when there is obviously not a complete obstruction, it may be desirable to give barium by mouth and watch its progress by x-ray examination. If there still is doubt as to the type of obstruction, a barium enema may make the diagnosis definite.

The relief of patients with the intrinsic type of obstruction of the duodenum has been undertaken in several different ways, and quite different methods have met with success. Posterior gastrojejunostomy has perhaps been the operation most frequently used and is without question easier to perform than some of the others. This operation has definite disadvantages that were very striking in one of our series. A female infant with intrinsic type of stenosis had a posterior gastroenterostomy performed at the age of six days. The progress was quite satisfactory up to the fifth month of life. At that time the child refused to eat and lost weight. She was placed under excellent pediatric care for two months without improvement. X-ray examination showed that the stoma between the stomach and jejunum functioned very well and that the stomach emptied satisfactorily, but on fluoroscopic examination some of the barium was seen to pass through the pylorus into the duodenum, meet the obstruction, and return by the same route. Examination of the stomach contents showed absence of acid. At the seventh month of life, a posterior duodenojejunostomy was done which was followed by relief and return of normal appetite and development. Webb and Wangensteen have reported a similar experience. Although gastrojejunostomy has met with some success in this series and in other reports, it is not a logical operation for relief of duodenal obstruction. This operation is, theoretically, particularly unsound in the cases of atresia of the duodenum, since in this situation the bile must go back into the stomach, neutralizing the acidity and causing anorexia. Antecolic duodenojejunostomy has been performed successfully by Donovan in five cases. While this operation does not have the drawback of a posterior gastrojejunostomy, it would seem that it might have others. The difficulties are those of having the stoma low enough to adequately drain the duodenum, which is mentioned by Donovan, or the possibility that enlargement or distention of the colon

tion have been successful in other clinics. . Of these, the one that seems most logical is the plastic operation on the duodenum described by Morton.

For the extrinsic type of duodenal obstruction it seems clear that the transposing operation described in this paper and in earlier communications is the operation of choice. Reduction of volvulus alone is not sufficient to permanently relieve the obstruction of the duodenum due to malrotation of the midgut.

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gut volvulus, has become quite well standardized at this hospital and with gratifying results. Prior to adopting our present type of procedure, we had attempted to relieve these patients in various ways but with no success. The present procedure consists in making a right paramedian or right rectus incision of adequate length, next delivering the whole midgut and unrotating the volvulus if there is one present. In one or two instances this procedure alone appeared to relieve the obstruction at the time of operation but later proved to be insufficient. The next step in the operation consists in mobilizing the cecum, ascending colon, and proximal half of the transverse colon from right to left until such time as the duodenum is completely visible. If at this time there are any extra folds of peritoneum or bands which impinge on the duodenum and constrict it, they are severed, care being taken, of course, not to injure the superior mesenteric artery. Since adopting this type of operation, there have been twenty-three patients operated upon. Nineteen of these have recovered and have been followed for varying lengths of time from a few weeks up to several years. They have developed normally and without return of abdominal symptoms. Of the four who died, one died of pneumonia three weeks after operation, and one patient, six days old, who had an exfoliating skin lesion, died two days later. At the time of death the skin lesion had become much worse and a diagnosis of pemphigus neonatorum was considered. The other two patients died within two days of operation and might be considered as immediate operative deaths. (Table II.)

TABLE II

OPERATIVE TREATMENT OF EXTRINSIC OBSTRUCTION OF DUODENUM

OPERATION	NO. CASES	RECOVERIES	DEATHS
Anterior gastroenterostomy	1	0	1
Anterior duodenojejunostomy	1	0	1
Reduction of volvulus	1	0	1
Ladd's operation	23	19*	4
Total	26	19	7

*Two of these patients had had previous reduction of volvulus with recurrence of symptoms.

CONCLUSIONS

It seems fair to conclude that if the obstetrician and the pediatrician will regard vomiting of the newborn infant as a signpost demanding investigation of the alimentary tract, many infants may be given a chance for life which was formerly denied them. Posterior duodenojejunostomy is the operation which has proved most successful in our hands to relieve intrinsic duodenal obstruction. Other types of opera-

The groups of coils developing from these six primary coils can be recognized roentgenographically when the intestine is filled with an opaque medium, such as a water suspension of barium sulphate, or after moderate distention with air which usually occurs when the intestine is obstructed. The first coil forms the duodenum. The second, third, fourth, fifth, and sixth groups of the coils are the mesenteric small intestine.

Duodenum.—We consider that the duodenum begins at the first crescentic or annular fold distal to the pyloric valve and extends to the duodenojejunal flexure. L. G. Cole has frequently called attention to the fact that the short segment of intestine between the pyloric valve and the first *valvula connivens* should be considered as part of the stomach or as a separate part of the intestinal tract and not as part of the duodenum. He gave the name of *cap* to this segment. It is developed from the foregut as is the stomach, while the duodenum and mesenteric small intestine are developed from the midgut.

The duodenum is relatively fixed in position in the form of a loop, the opening of the loop facing to the left and superiorly. The concavity of the loop encircles the head of the pancreas and usually corresponds in size to the head of the pancreas. There are several normal shapes of the loop of the duodenum. The duodenum may be shaped like the capital letters C, V, and U or may be almost rectangular, depending upon the relative position and angulation of the superior, descending, and inferior parts. Due to its relative fixation in a retroperitoneal position, the general form of the loop of the duodenum remains unchanged and is readily recognizable even when markedly distended with air or fluid.

Duodenojejunal Flexure.—This is, as a rule, the highest fixed point of the small intestine. The inferior duodenum usually ascends to the flexure. The flexure is suspended by the fibromuscular ligament of Treitz which passes down behind the pancreas from the lumbar part of the diaphragm. The intestine is only occasionally held to a point at the duodenojejunal flexure. Usually the intestine makes a moderate curve on itself, and less commonly the curve is very wide. The curve at the flexure is usually from posterior to anterior, and in many individuals the angle of the curve can be appreciated only when it is viewed in the oblique or lateral direction. Occasionally the intestine a short distance distal to the flexure is caught up at a second point of fixation, forming a short loop of intestine.

Mesenteric Small Intestine.—The mesenteric small intestine is composed of the second, third, fourth, fifth, and sixth groups of coils of the small intestine. The second group of coils is formed by the intestine as it leaves the duodenojejunal flexure, and the coils lie in the left hypochondriac region. At the distal end of this group, the in-

THE GENERAL PATTERN AND LOCATION OF THE SMALL INTESTINAL COILS

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DETERMINING the level in the small intestine at which a pathologic process exists is facilitated by the fairly constant anatomic situation and grouping of the small intestine and the characteristic appearance of its various major divisions. The differentiation of the duodenum and jejunum above and the ileum below is easily made by the presence of numerous high mucosal folds in the duodenum and jejunum, inasmuch as these characteristic folds are not obliterated even by marked distention of the intestine. It is possible to make five differentiations in the jejunum and ileum because of the characteristic grouping and situation of their coils in the abdomen.

The arrangement of the small intestine into six primary groups of coils is recognized in both the embryo and the adult. C. M. Jackson in his section on the digestive system in *Morris' Anatomy*, eighth edition, states:

"Even in an embryo of 18 mm., while the intestine is still in the umbilical celom, Mall described six primary coils of the small intestine which could still be recognized after the return of the intestines to the general body cavity, and could usually be identified even in the adult (Fig. 942). In the adult, as also through the various stages of development, loop one forms the duodenum. From the primary groups of coils marked 2 and 3 are developed the greater part of the jejunum, arranged in two distinct groups of loops, situated in the left hypochondriac region. The part of the intestine developed from group 4 of the primary coils passes across the umbilical region to the right upper part of the abdomen. That part developed from group 5 of the primary coils recrosses the median line to the left iliac fossa, while that part derived from group 6 of the primary coils is formed in the false pelvis and the lower part of the abdominal cavity between the psoas muscles. They present what may be regarded as the normal arrangement of the small intestine, having been found 21 times in 41 cadavers examined. Variations from this arrangement occur; the great majority of such variations are, however, not of sufficient importance to require special mention."

the terminal loop ascending from the pelvis into the right iliac fossa to enter the left side of the cecum. The situation of the fourth and fifth groups of coils as observed roentgenographically is somewhat at variance with the description given above by Jackson.

Distinct visualization of the fourth, fifth, and sixth groups largely depends upon the build of the individual. In hypersthenic individuals most of the loops are out of the pelvis, the liver is high, and the loops can be individually recognized. In asthenic types of individuals the



Fig. 2.—One-half hour after the barium meal, showing barium in the stomach and the first five groups of coils. Figs. 2, 3, and 4 show the same case.

liver is relatively low in position and the loops of the lower groups of coils may be so massed together in the lower part of the abdomen that it is impossible to recognize their outlines. Upward displacement of the intestines by a filled urinary bladder also tends to mass the loops together.

There is also a characteristic arrangement of the intestinal loops within the groups of coils. In the second and third groups of coils the individual loops lie transversely in the abdomen, and in the fourth,

testine loops toward or beyond the median line to the region of the root of the mesentery and then back to the left to form the third group of coils.

The third group of coils lies in the left lumbar region and may descend into the left iliac region. After forming this group of coils, the intestine loops to the right of the median line in the region of the root of the mesentery and then forms the fourth group of coils. The



Fig. 1.—One hour after a barium meal, making visible the six groups of coils, stomach, and cecum.

various loops of the second and third groups are quite discrete. Only when they are confined within a relatively small area are they massed together so that the individual loops cannot be recognized.

The fourth group of coils is usually observed in the umbilical and upper hypogastric regions but may extend into the right hypochondrium. The fifth group of coils is usually found in the right lumbar region extending down into the right iliac region. The sixth group of coils is usually located in the lower hypogastric region and pelvis.

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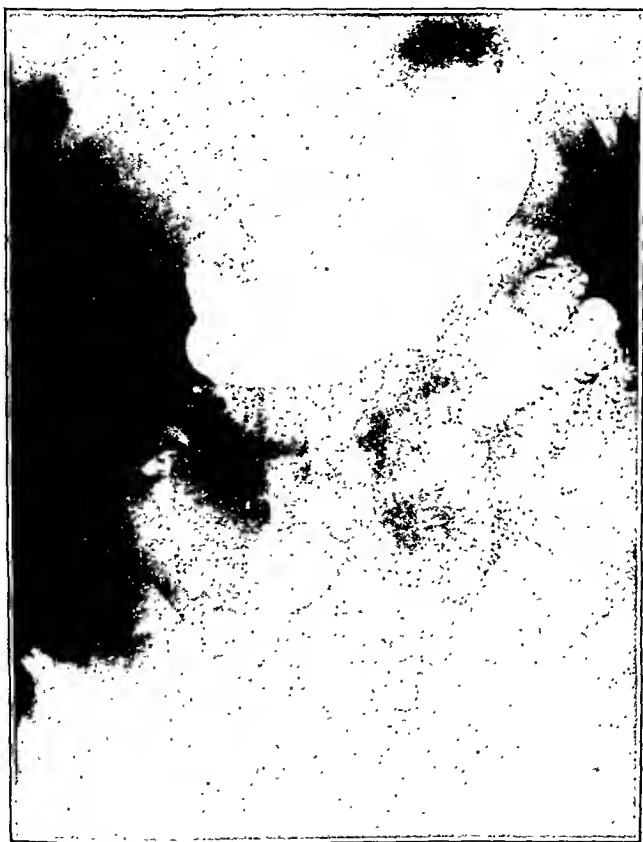


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There is also a characteristic arrangement of the intestinal loops within the groups of coils. In the second and third groups of coils the individual loops lie transversely in the abdomen, and in the fourth,

fifth, and sixth groups the individual loops lie vertically. Between each group of coils a relatively longer loop of small intestine extends back to the root of the mesentery. This formation is most characteristically seen between the second and third groups of coils.

Displacement of the first and second groups of coils into the right hypochondrium and lumbar region is the rule in association with incomplete rotation of the colon. Rarely it occurs as an isolated abnormality. In both instances, the duodenojejunal flexure may be displaced



Fig. 3.—One and one-half hours after meal. The head of the meal is at the splenic flexure. The distended bladder displaces the fourth and sixth groups upward.

out of its usual position. Another unusual anomaly is to have the upper loops of the mesenteric small intestine festooned across the upper abdomen.

Motor Phenomenon of Small Intestine.—Food or other substances in the small intestine are propelled through the gut by peristaltic contractions which may develop at any level and progress analward. The most proximal wave begins in the middle of the cap, partially emptying the cap, and progresses through the duodenum to varying levels in the mesenteric small intestine. The first bolus of barium evacuated from the cap may be carried as far as the fourth group of coils before

the peristaltic contraction disappears. Under normal conditions the rate of progress of the peristaltic contraction is more rapid in the upper part of the small intestine. In the duodenum and second, third, and fourth groups of coils it progresses at the rate of two to four centimeters per second. In the lower part of the small intestine the wave of peristalsis moves much slower, usually less than one centimeter per second. Under normal conditions of irritability the longitudinal length of a peristaltic contraction wave is approximately one centimeter. With abnormal irritability, the longitudinal length of the peristaltic wave is increased as is also its rate of progress.



Fig. 4.—Two and one-half hours after meal. Bladder empty, allowing the coils to drop down.

Progressive peristaltic contractions are frequently preceded by stationary tonic contraction rings. As a tonic contraction becomes a progressive peristaltic contraction, there may be many abortive attempts at progression. During fluoroscopic examination of the small intestine we have never observed to-and-fro movements of the barium. The nearest approach to this phenomenon has been the change in the barium shadow produced by these abortive attempts at progression in tonic contraction rings situated fairly close together in the intestinal muscle.

Caliber of the Lumen of the Small Intestine.—In the living subject the intestine is normally in a state of tonic contraction; it is contracted on itself or its contents. For this reason the caliber of the lumen of any section of the small intestine will depend upon the degree of filling or distention. Certain normal variations in the rapidity of emptying of the stomach and the rapidity of passage of the meal through the small intestine will, therefore, modify the distribution of the meal and the pattern of the intestine. Rapid uniform emptying of the stomach will give a large caliber to the intestine throughout



Fig. 5.—Atypical arrangement of the groups, the third and fourth groups being to the right and the fifth to the left of the median line. The second group is slightly to the right of its normal position.

the entire length in which the meal is present. With slow or moderately rapid emptying of the stomach, the caliber of the lumen of the intestine will be small or moderate if the passage of the meal through the intestine keeps pace with the emptying of the stomach. If the passage of the meal through the intestine is more rapid than the entrance of the meal into the intestine, the caliber will be small, but usually uniform. If the stomach empties itself intermittently, the distribution of the meal and the caliber of the small intestine will be irregular.

Pattern Produced by Obstruction of Small Intestine.—The root of the mesentery of the small intestine runs obliquely downward from the region of the left upper quadrant and across the midline to the right lower quadrant, a distance of six to eight inches, and is attached to the posterior abdominal wall. The anterior border of the mesentery is attached to the small intestine and is necessarily as long as the gut, about twenty-two feet. Due to the great length of the small intestine



Fig. 6.—Pattern produced by marked distention of the second, third, and fourth groups of coils due to obstruction in the upper ileum. In spite of the marked distention, the markings of the primary mucosal folds are retained.

and the limiting space of the abdominal cavity, the mesentery is arranged in a folded or frilled fan-shaped manner; the small intestine itself is in a collapsed or slightly distended state and arranged in groups of coils as described above. The second and third groups of coils of the small intestine lie usually to the left of the root of the mesentery; the fourth group lies on both sides; the fifth lies to the right, and the sixth to the left with some overlapping to the right.

The individual coils in the groups are produced by the varying length of the mesenteric attachment, the ends of the coils having a short mesentery and the looping portion having a progressively longer attachment. These coils normally fold on themselves to form short loops, although this folding pattern does not remain fixed.

The pattern produced on the roentgenogram in any case of obstruction of the small intestine is determined by the following factors: (1) Site of obstruction, (2) degree of gas distention, (3) length of gut distended, (4) the closed abdominal space.

When an obstruction occurs at any point in the small intestine, the gut proximal to this area becomes gradually distended with air, the amount of distention depending upon the degree of obstruction, the elapsed time, and the amount of air swallowed by the patient. We have always been under the impression that distention of the small intestine due to obstruction causes an elongation of the gut as well as an increase in the diameter. Sperling and Wangenstein,¹ however, in producing acute obstruction in dogs, noted a definite shortening of the bowel which in some instances amounted to as much as 33 per cent. These findings are directly the reverse of what happens in distention of the stomach and colon; here we can easily visualize an increase in length as well as diameter by means of the roentgen examination. The distention of the small intestine, when marked, causes an obliteration of all but the permanent mucosal folds, the latter causing a constriction of the wall which results in a characteristic pattern that can be likened to stacked, miniature balloon tires. Occasionally in cases of chronic obstruction of the small intestine, even these primary mucosal folds may be wiped out. With distention the individual coils unfold and are displaced out of their relatively normal positions by the internal pressure. Thus we may see a continuous coil of distended gut passing across the entire abdomen turn on itself and swing back toward the root of the mesentery, from where another coil may swing away in a different direction, the ends of the coils being held near the root of the mesentery by their shorter attachments. Occasionally a case is seen in which a relatively short length of small intestine, ten to twelve inches, is distended with air; these short loops are always curved, indicating the influence of the mesentery on the pattern produced.

The distended coils of the second group tend to assume a horizontal position across the abdomen, usually not extending very far beyond the midline to the right; the coils of the third group extend horizontally across the abdomen. The distended coils of the fourth, fifth, and sixth groups tend to assume an oblique and vertical position in the abdomen.

In a case showing marked distention of the bowel, it may be impossible to distinguish distended colon from distended small intestine on the roentgenogram. It is then advisable to administer a barium

enema to determine the presence or absence of obstruction in the colon. A diagnosis of an obstructing lesion in the colon distal to the cecum is important information to the surgeon in determining his operative procedure. In no case of complete obstruction should a barium meal be given by mouth as the impaction of the barium that results will create an added hazard to both the surgeon and patient. If one decides that barium by mouth may give additional important findings, small amounts of a thin watery mixture may be used, and then only in cases of partial obstruction.

The differential diagnosis between complete mechanical obstruction of the colon, paralytic ileus, and mesenteric thrombosis is often extremely difficult when there is marked distention of both the large and small bowel in these conditions. The barium enema examination usually detects the presence of a mechanical obstruction. Visualization of the entire colon by means of the barium enema in the absence of an obstructing lesion limits the diagnosis to a paralytic ileus or mesenteric thrombosis, an impossible differential diagnosis by means of the roentgen examination. However, early in mesenteric thrombosis there is no distention of the gut with air, and when a barium meal is given by mouth, the head of the column stops in the second or third group of coils, the stomach retaining most of the meal. Practically no change will occur in the progress of the meal for as long as forty-eight hours or until vomiting and gas distention of the bowel occur. The diagnosis of mesenteric thrombosis is very rarely made before gas distention of the gut is present, and even then a positive differential diagnosis is usually impossible.

Large amounts of fluid or semifluid fecal material in the distended bowel may and usually do give an atypical pattern on the roentgenogram; large collections of gas may not be present, occurring only as numerous small bubbles quite uniformly mixed with the fluid. In such cases, the contrast between gas-distended bowel and surrounding soft tissue shadow is considerably diminished due to the density of the fluid. If the roentgenogram is made in the upright posture, fluid levels will be seen in the loops of distended gut.

It is sometimes possible to determine quite accurately at which level in the small intestine an obstruction exists, but usually this is difficult to do with any degree of certainty, particularly when the obstruction is low with many distended and superimposed coils filling the abdominal cavity. However, the roentgenologist can frequently direct the surgeon where to make his incision for the nearest approach to the obstructing lesion.

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FUNDAMENTAL CONSIDERATIONS IN THE OPERATIVE
TREATMENT OF ADVANCED INTESTINAL OBSTRUCTION
WITH ESPECIAL REFERENCE TO THE MANAGEMENT OF
CASES COMPLICATED BY GANGRENE OF THE INTESTINE

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TREATMENT of bowel obstruction should be planned to cure the bodily injuries which obstruction produces. I begin, therefore, with a discussion of the nature and extent of these injuries. This, I hope, will justify in the mind of the reader the treatment I advocate. Authorities on bowel obstruction seem now to be in substantial agreement in regard to the chief effects thereof as given in the following summary.

SYSTEMIC EFFECTS OF OBSTRUCTION

Dehydration and the starvation always associated with it are the chief causes of death following untreated obstruction.

Obstruction of the small intestine causes a prodigious loss of water and electrolytes by the blood. This dehydration is nearly always accompanied by an alkalosis. It accounts for the rapid, feeble pulse and low blood pressure observed in patients with ileus. It accounts also for the failure of the kidneys to excrete nitrogenous wastes. The increased viscosity of the blood may cause obstruction of the intrinsic arteries of the heart if these are already narrowed by sclerosis. It makes weaker the already enfeebled circulation through the bowel wall. It deranges the entire metabolism.

We shall discuss later the possibility that systemic effects are under certain conditions produced by toxins absorbed from the obstructed bowel.

EFFECT OF OBSTRUCTION ON THE BOWEL

These on final analysis are due to interference with circulation, caused, (1) by distention, (2) by direct pressure on the bowel, and (3) by obstruction of the blood vessels of the mesentery.

Effects of Distention on the Bowel.—As the intrainstestinal pressure increases, the quantity of blood flowing through the intestinal wall decreases. The flow ceases entirely when the intrainstestinal pressure equals the systolic blood pressure. Distention alone can cause necrosis of the bowel wall. The bowel, however, endures the anemia caused by distention astonishingly well. The writer has demonstrated that

detached pieces of rabbit intestine remain alive in Ringer's solution for twelve to fifteen hours. Under clinical conditions the bowel probably remains viable much longer than this when distention is the sole impediment to its circulation. The pressure within it will take a long time to reach a height sufficient to cut down the blood flow to a dangerous extent; furthermore, regurgitation of its contents will keep down the pressure. It is to be noted that prolonged distention, even though it may not injure the bowel beyond possibility of recovery, may conceivably damage the mucosa enough to make it permeable to toxins.

While the large bowel can resist the effects of distention for a longer time than the small bowel, it is much more liable to ultimate injury thereby. This is because the colon cannot readily empty its contents backward into the small intestine. The muscular coat of the bowel loses the power to contract when stretched beyond a certain extent. When this occurs the bowel can no longer protect itself against distention by evacuation of its contents. A bowel which has been over-distended for some time regains but slowly the power to contract. For this reason a short-circuiting operation or even enterostomy may not relieve obstruction for several days.

Effects of Direct Pressure on Bowel Wall.—Direct pressure upon the bowel wall by an impacted foreign body, e.g., by a gallstone or by the neck of a hernia or a peritoneal band, may cause necrosis thereof. The danger of this is increased by intestinal distention. Areas of bowel weakened by this cause are common sites of perforation.

Effects of Interference With the Mesenteric Blood Vessels.—Clinically, this is the most common and dangerous cause of circulatory disturbance in the bowel wall. In the form of interference most frequently encountered, the mesenteric veins are obstructed while the mesenteric arteries are not, for example, incarceration of the bowel in hernia or beneath a peritoneal band. Under these conditions blood flows into the wall of the bowel under the full force of the systolic blood pressure but cannot leave it. We have shown that this subjects the capillaries of the bowel to the full force of the systolic blood pressure. This ruptures the capillaries and rapidly demolishes the entire bowel wall.

ABSORPTION OF TOXINS FROM OBSTRUCTED BOWEL

Before the discovery that intestinal obstruction causes a profound dehydration, death from all forms of intestinal obstruction was attributed to the absorption of poisonous materials from the bowel. This theory dominated treatment until recent years and was the cause of an enormous amount of experimental work, the major portion of which is now of historical interest only. Our present-day view of the intoxication theory, briefly stated, is as follows: The content of ob-

FUNDAMENTAL CONSIDERATIONS IN THE OPERATIVE TREATMENT OF ADVANCED INTESTINAL OBSTRUCTION WITH ESPECIAL REFERENCE TO THE MANAGEMENT OF CASES COMPLICATED BY GANGRENE OF THE INTESTINE

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TREATMENT of bowel obstruction should be planned to cure the bodily injuries which obstruction produces. I begin, therefore, with a discussion of the nature and extent of these injuries. This, I hope, will justify in the mind of the reader the treatment I advocate. Authorities on bowel obstruction seem now to be in substantial agreement in regard to the chief effects thereof as given in the following summary.

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trary is true in all but early cases. The diagnosis of advanced ileus is a contraindication to operation until the patient has been prepared therefor. This preparation consists essentially (1) in the relief of starvation, dehydration, and alkalosis by the parenteral administration of adequate amounts of salt solution and glucose and (2) in the relief of gastric and intestinal distention. The second of these requires extended comment.

When the obstruction is in the large bowel beyond the cecum and is complete, it is our practice to relieve it by a cecostomy, performed through a McBurney incision by amputating the appendix and dilating the opening through the cecal wall until it will admit a good-sized tube. This is then inserted to a length of several inches and the end of the cecum is invaginated around it on the principle of a Seun gastrostomy by two or three superimposed purse-string sutures of catgut. The tube is pushed through a flap of omentum which is tucked around the cecum, and the peritoneum is tightly closed about it. The other layers of the abdominal wall are very loosely sutured. We have been able nearly always to empty the colon in this way and have observed little or no fecal drainage after removal of the tube. It may require a week or longer to empty the colon and to give it time to regain a healthy tone. Then resection can be done with comparative safety and a death rate which should not exceed 5 per cent. Resection at an earlier time is difficult and dangerous. Between cecostomy and resection the patient should be given a full, low-residue diet.

If the obstruction is situated anywhere from cecum to pylorus, we now relieve distention by continuous gastric lavage. We formerly relied on a Witzel jejunostomy for this purpose, but we have found the lavage equally efficient except for very advanced cases. It takes the courage of conviction to persist in the attempt to deflate the bowel for perhaps several days. Our clinical experience, however, has now been sufficient to justify this treatment. It must be remembered that an overdistended bowel regains very slowly the power to contract; also, that it can be trusted to retain its viability for a long time. The slow relief of the distention is a safeguard against an overwhelming absorption of toxic material. Several of our patients, apparently in a hopeless condition on admission, were cured by the treatment just described, without any operation at all. In these it is possible that the obstruction was due to a kinking of the bowel over a peritoneal band and that the relief of the distention undid the kink. Patients so relieved should, of course, be kept under close observation for a long time.

How long should the attempt to deflate the small bowel be kept up? In general, the more slowly deflation is accomplished, the more neces-

structed bowel is less toxic on intravenous injection than the content of normal bowel. The healthy intestinal mucosa prevents the passage into the blood stream of any toxic material conceivably present either in normal or obstructed bowel. The absolute proof that toxic material is absorbed from the obstructed bowel has never been produced. There are good reasons for believing that the body is protected in a fairly adequate way from such absorption. Two of these are the following:

1. When the mesenteric vessels are obstructed, nothing but transperitoneal absorption can take place. This is probably slight, because patients often live for days with pieces of gangrenous intestine without showing noteworthy signs of intoxication. The peritoneum can isolate a loop of gangrenous bowel as readily as it can an abscess.

2. Distention itself, if due to an intrainestinal pressure higher than the diastolic blood pressure, prevents all absorption from the bowel by way of its mesenteric vessels, even though the mucosa be damaged. Since untreated bowel obstruction is accompanied by a marked fall in the blood pressure, it is probable that the intrainestinal pressure in any damaged loop of bowel will be as high as the diastolic blood pressure and that, therefore, no absorption from it can take place.

Absorption of toxins can occur only in the presence of a devitalized intestinal mucosa and an adequate circulation through the bowel wall. These conditions are present when the intestinal mucosa has been partially devitalized by prolonged and great distention which is rather suddenly relieved. They might be present also after a low blood pressure had been elevated by the administration parenterally of a considerable quantity of water and electrolytes. This elevation of blood pressure, together with the decrease in viscosity of the blood which accompanies it, can conceivably restore the flow of blood through a distended loop of intestine, which before had been almost without circulation, and which, because of this fact, had a devitalized mucosa.

Most surgeons have observed patients collapse or die with symptoms suggestive of profound intoxication after the abrupt relief of a bowel obstruction. The writer has never observed an outcome of this kind following the administration of considerable quantities of fluid, but the possibility of its occurrence in advanced cases of ileus is worthy of thought.

TREATMENT

Diagnosis is outside the scope of this paper. Suffice it to say that before operative treatment is undertaken, the presence, site, and stage, whether early or late, of the obstruction should be determined.

We are of the opinion that the appalling death rate following operation for bowel obstruction has been in great part due to the idea that the diagnosis is an indication for immediate operation. The con-

Operation: June 26, the abdomen was opened through a suprapubic incision. A greatly distended, totally gangrenous loop of bowel was found in the pelvis. It had been strangulated by passing around the right round ligament between the uterus and the anterior abdominal wall. It was ruptured while being removed, but its escaped contents were quickly and completely removed from the pelvis by aspiration. A gun-barrel enterostomy was done. Omentum was disposed around the emerging ends of bowel. Penrose drains without gauze were inserted into the bottom of the pelvis and brought out below the enterostomy. The incision was closed in layers with a continuous suture of plain catgut for the peritoneum and loosely applied chromic catgut sutures for the anterior sheaths of the recti. The skin was partially closed with interrupted sutures of silk.

Postoperative course was relatively uneventful. The treatment for about three days was the same as before operation, except that water was given through the distal end of the enterostomy instead of by vein. Then the Levine tube was removed and soft food and fluids given by mouth. There was no excoriation of the wound, which was kept clean by manually applied suction. Because of the generally poor state of the patient, closure of the enterostomy was deferred until July 22—twenty-six days—when her condition was excellent.

The wound was reopened, the bowel ends freed, and a lateral anastomosis done. The abdomen was closed completely except for a Penrose drain inserted down to the posterior surface of the uterus and carefully protected from the site of the anastomosis.

It is noteworthy that the wound healed almost by primary union, although three weeks after operation, when the patient was at home, she developed a small abscess at the lower end of the incision. She has since remained in good health.

CASE 2.—White man, aged twenty-two years. Admitted on January 29, 1937. Discharged March 3, 1937. Complaint: severe, crampy pain in the epigastrium. Vomiting began ten hours after onset, never fecal. Passed a little gas and some solid material with enema.

He had had appendectomy in August, 1936. Health had been good until onset of present illness.

Seen in consultation on February 2. General condition good except for moderate dehydration. Abdomen was somewhat distended; bowel sounds present. A very tender sausage-shaped mass felt above and parallel to Poupart's ligament; tense mass felt by rectum in right side of pelvis.

White blood count 27,500, with 92 per cent granulocytes. Urine negative. X-ray plate of abdomen showed normal colon and a ladder pattern of distended loops of small bowel.

Diagnosis: obstruction of small bowel with gangrenous loop. Continuous gastric lavage was started and 2,000 c.c. of normal salt solution with 5 per cent glucose given by vein.

Operation: (Dr. John Owen.) February 2, 1937. A gangrenous loop of terminal ileum 40 cm. long, obstructed by a band due to the appendectomy, was removed and a gun-barrel enterostomy done. Abdominal wall was closed as described for Case 1.

Postoperative course entirely uneventful. No wound complication. On February 26, 1937, the distal end of the enterostomy was invaginated into the cecum, and a lateral anastomosis done between the proximal end of the ileum and the ascending colon. Recovery was uneventful.

CASE 3.—White boy, aged fifteen years. Admitted January 12, 1933. Dismissed March 5, 1933.

Onset five days before admission with abdominal cramps and vomiting. Vomitus bile-tinged for three days, never fecal. General abdominal soreness since onset. Dark blood in stools for last two days.

sary it is. It may be completed in a few hours in early cases. In advanced cases, it may be impossible to deflate completely the lower reaches of the obstructed bowel. Sometimes placing the patient on his side or in the prone position may be a great aid to deflation. It is safe to operate when abdominal distention has been greatly reduced, when borborygmi can be heard, and when the general condition of the patient is good.

If the site of the obstruction has been determined with fair accuracy, the operator can make the abdominal incision which will permit the best possible exposure of the lesion. It is needless to dwell upon the difficulties and dangers of this exposure in the presence of greatly distended loops of bowel. If there is no gangrene of the intestine, simple relief of the obstruction is all that is required. If the contrary is true, we believe that gun-barrel enterostomy following removal of the gangrenous piece of bowel is the best treatment. We never perform intestinal anastomosis at this time. The patient, despite all efforts to improve his condition, is still a poor risk for operation; the over-stretched bowel is in no condition for suturing, which is followed too often by death.

The fear of leaving a gangrenous piece of bowel in the abdomen is, I believe, the reason which prompts many surgeons to operate upon patients with advanced ileus as soon as possible. My experience has led me to believe that, even if this formidable complication is suspected, it is safer to defer operation until the preparations described above have been made. As already stated, the peritoneum can wall off a piece of gangrenous bowel as readily as it can an abscess, and the one may be attended by no more systemic disturbance than the other. I submit case reports of three consecutive cases to enforce this point.

CASE 1.—White woman, aged thirty-eight years. Admitted June 23, 1936. Discharged August 6, 1936. Complaint: severe abdominal pain, nausea, and vomiting. Onset June 21, sudden, while on a 200-mile auto trip; required morphine.

In March, 1934, the patient had had a double salpingectomy, Gilliam suspension, and removal of a small cyst from one ovary. A year before admission she had had a short attack similar to the present one.

The patient was acutely ill, in extreme dehydration. The abdomen was distended, and there was marked tenderness and muscular defense above the pubis. No bowel sounds were heard, but some gas had been expelled with an enema. The uterus was of normal size and in normal position. Behind it the pelvis was filled by a tense boggy mass.

Temperature, 101°; pulse, 120; respirations, 24; white blood count, 14,050 with 94 per cent polymorphonuclear cells. The urine contained albumin, casts, and red blood cells. X-ray examination revealed a ladder pattern of distended loops of small intestine.

Treatment consisted of morphia, continuous gastric lavage, and intravenous injections of salt solution and glucose. The abdominal distention became markedly reduced and bowel sounds could be heard. The temperature remained around 101°.

HERNIA AS AN ETIOLOGIC FACTOR IN ACUTE INTESTINAL OBSTRUCTION

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HERNIA provides potentially those anatomic and mechanical conditions which are generally recognized as essential to the production of intestinal obstruction, and it is not extraordinary to find that the therapeutic methods of the preantiseptic period made little progress in limiting the incidence of this complication. It was, however, to be anticipated that the advent of asepsis, inaugurating the modern era of surgery and establishing the efficiency of the open methods of treatment, might promise a popularization of these methods and, in consequence, prognosticate a prophylactic reduction of this dreaded obstructive complication. That this promise has to some degree been realized is amply attested by the fact that open operation for radical cure of hernia is today one of the most commonly performed procedures in the whole field of general surgery. On the other hand and in spite of the widespread attack upon this potential source of major complications, the inescapable fact remains that, relatively and absolutely, hernia at this time continues to head the list of causes of acute intestinal obstruction.

So far as our own material is concerned, the answer to this enigma is to be found not so much in statistical data as in certain sociologic and psychologic factors which must be given due consideration if these data are to be correctly interpreted. For example, the figures constituting the present report are based upon clinical material drawn almost exclusively from a social stratum which is traditionally antagonistic to the principle of prophylaxis and which views surgical therapy as a kind of Pandora's box whose powers are to be invoked only as a last resort. Reference to the records of our series of acute intestinal obstruction due to hernia discloses eloquent evidence of this state of mind which may justly be held accountable for the significant facts that 82.8 per cent of the group were victims of hernia for periods varying from two years to forty years preceding the onset of the final obstructive manifestations; that more than half the cases had been obstructed for twenty-four hours to ten days before seeking treatment; and finally, and in consequence of the foregoing, that the group as

Past history uninforming except that patient had had "stomach upsets" at intervals since birth.

Physical examination showed the boy to be in good general condition except for dehydration. Abdominal distention was not great. There was marked muscular defense and tenderness over the *McBurney* region. A mass could be felt by rectum in the right side of the pelvis.

Temperature, 100; pulse, 106; respirations, 18; white blood count, 19,950 with 80 per cent granulocytes. Urine negative.

A diagnosis of appendical abscess with associated bowel obstruction was made. After a short period of gastric lavage and the administration of 1,000 c.c. of salt solution by vein, operation was performed.

A *McBurney* incision was made, whereupon the true nature of the trouble was discovered. A gangrenous piece of bowel was found in the pelvis. The *McBurney* incision was closed, and a suprapubic incision made. The gangrenous piece of bowel was resected. It proved to be a double intussusception of the ileum of uncertain origin. A gun-barrel enterostomy was established and the wound closed as described for Case 1.

The obstruction had evidently been high, because there was great excoriation of the skin around the enterostomy. Nourishment and water were given through the distal limb of the enterostomy. Continuity of the bowel was restored by lateral anastomosis on February 16, 1933. Recovery was then uneventful with good healing of the wound. The boy has remained well.

COMMENT

The interval between operations could have been shortened with safety in all of these cases. Its length will depend in any given case upon the general condition of the patient and the time required for intraabdominal or wound abscesses to heal. The bowel, atonic because of prolonged overdistention, may not resume a normal tone for several days after enterostomy. During this time the patient's nutrition cannot be improved. The second operation for these reasons cannot usually be done sooner than two weeks after the first.

Our experience with these patients demonstrates that gangrene of the bowel may cause amazingly little intraabdominal or systemic disturbance; that the fear of its presence should not lead to operation before the patient has been prepared therefor; that with proper pre-operative preparation followed by excision of the gangrenous bowel and enterostomy, this serious complication of bowel obstruction can be successfully treated.

TABLE I

ANALYSIS OF 130 CASES OF HERNIA WITH INTESTINAL OBSTRUCTION

TYPE OF HERNIA	NUMBER	SEX		AVERAGE AGE	AVERAGE DURATION OF SYMPTOMS	DEATHS	MORTALITY RATE
		M	F				
Indirect inguinal	79	76	3	39.3	39.1 hr. (71 cases)	12	15.0%
Direct inguinal	7	4	3	52.0	43.4 hr. (6 cases)	1	14.0%
Femoral	26	8	18	55.3	67.2 hr. (25 cases)	15	57.5%
Umbilical	7	0	7	55.2	47.3 hr. (6 cases)	4	57.0%
Ventral	8	1	7	51.0	46.5 hr. (6 cases)	4	50.0%
Interstitial	1	1				1	
Semilunar	1	1				1	
Internal	1	1				0	
Group, totals	130	92	38	44.1 (130 cases)		38	29.23% (130 cases)

predominate over females in the ratio of 92 to 38; that the average age for the group as a whole is 44.1 years; and that there were 38 deaths, establishing a mortality rate of 29.23 per cent.

It is apparent from comparative study of the various types comprising this group (Table I) that, while the indirect inguinal variety with 79 cases predominates among the causes of hernial obstruction, it presents at the same time the lowest figures for duration of acute symptoms (39.1 hours) and age of onset (39.3 years), both of which factors undoubtedly have a significant bearing upon the minimum mortality rate of 15 per cent recorded for this type of hernial obstruction. On the other hand, femoral hernia, which is second in importance from the standpoint of frequency, with 26 cases, shows the maximum figure for duration of acute symptoms (67.2 hours), the highest average age (55.3 years), and as a logical consequence, the maximum group mortality rate of 57.5 per cent. Among the less common obstructive hernias, the ventral, umbilical and direct inguinal types correspond very closely in respect to average age, duration of symptoms, and mortality rate, with the single exception that the latter (direct inguinal) is distinguished by its minimum mortality figure of 14 per cent. For the whole group, males preponderate over females in the proportion of 92 to 38, with the indirect inguinal type showing a special predilection for males, the femoral, umbilical, and ventral for females, while the direct inguinal hernias are about equally divided between the two sexes.

There were three instances in which obstruction complicated rare types of hernias. The first, a semilunar or Spiegel's hernia, occurred in a male of fifty-four years of age and presented clinical symptoms of

a whole presented a mortality rate approximating 30 per cent. It may, of course, be said in extenuation that this attitude toward hernia is not confined to any single class or group and that the very chronic nature and frequency of this condition bespeak a familiarity which breeds in general a contempt for its complications. Be this as it may, the fact remains that hernia is a potential source of acute intestinal obstruction, and prophylactic herniotomy is surely a small price to pay for insurance against the possibilities of this catastrophe.

The rôle of hernia as an etiologic factor in acute intestinal obstruction is indicated by an analysis of the records of the Fourth Surgical Division and the Children's Surgical Service, Bellevue Hospital, for the period from January 1, 1924, to January 1, 1937. Among the 52,351 surgical cases admitted during this period, 3,432 were classified as hernias of various types and of these latter 130 were associated with acute intestinal obstruction; whereas, during the same interval, the number of intestinal obstructions from all other causes combined totaled only 109 cases. On the basis of these figures, therefore, we may be permitted to conclude (1) that for this series the incidence of intestinal obstruction due to hernia, external and internal, is approximately 4 per cent and (2) that, while hernia constitutes but 6.5 per cent of general surgical conditions, it is, nevertheless, the inciting factor in 54 per cent of all acute intestinal obstructions.

In view of the fact that certain conditions may simulate but not actually qualify for inclusion in the group of acute intestinal obstruction due to hernia, it is necessary to establish specific criteria upon which to base the selection of cases comprising this group. It must be recognized, for example, that neither irreducibility or incarceration is necessarily synonymous with obstruction, and it is furthermore important to recall that pure omental hernias complicated by strangulation or torsion may, as a result of reflex peritoneal irritation, ileus, vomiting, and pain associated with characteristic local hernial signs, closely approximate the accepted clinical picture of obstruction. In consequence, the selection of cases for admission to the present series has been determined not only by the presence of the classic clinical symptoms of obstruction, but more particularly through the anatomic demonstration within the sac of an intestinal segment whose lumen, regardless of type of mechanism, has been encroached upon to such a degree as to preclude the maintenance of its excretory function.

As thus classified, there were 130 cases of acute intestinal obstruction induced by some type of internal or external hernia, and this number constitutes 3.8 per cent of all hernias admitted during the period of this study. Integration of this group shows that unless

INTERNAL HERNIA

The term internal hernia should properly include all those protrusions of intraabdominal contents through intraperitoneal pouches or openings of congenital or traumatic origin, thus contrasting with the common varieties of external hernias which take place through defects in the retaining wall of the abdomen. Although notably rare in

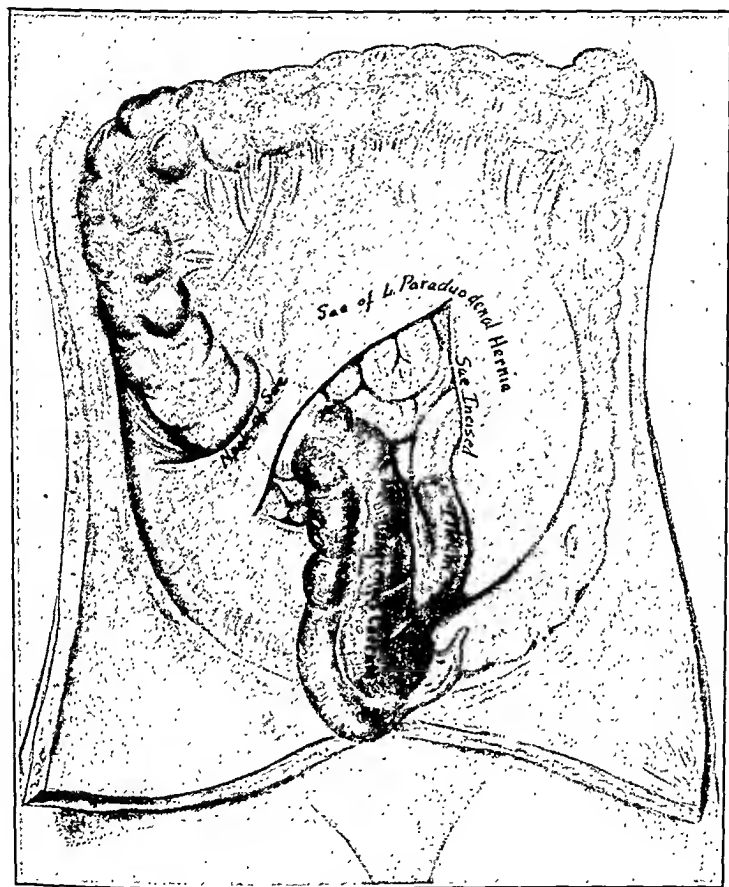


Fig. 1.—Drawing of left paraduodenal hernia (Case 1) to show neck of sac, exploratory incision of sac, and gangrenous segment of ileum and colon.

comparison with the external types, the internal hernias assume considerable clinical significance in consequence of the high incidence of acute intestinal obstruction which they exhibit. Short¹ mentions seven common types; viz., the retrocolic, the ileoappendicular, the intersigmoid and those through the foramen of Winslow, the transverse mesocolon and those into the paraduodenal fossae, right and left. Of this group, the last named, the paraduodenal, or retroperitoneal, hernia is of greatest importance from the clinical viewpoint and is differenti-

acute intestinal obstruction without demonstrable evidence of its site. At operation, there was found protruding through the left semilunar line just above Douglas' fold, a small sac containing a loop of small gut, which was constricted at its neck by a ring of posterior sheath through which it passed. The second instance was noted in a male of forty-five years of age admitted with a seven days' history of acute obstruction whose etiology was obscure. Exploration revealed a true interstitial hernia with a loop of proximal ileum angulated within a midline pouch of peritoneum presenting beneath the rectus muscle. Both of these cases were admitted in shock from neglected obstruction of undetermined origin and both died within twenty-four hours after operation, thus corroborating established conviction that this type of hernia frequently escapes detection and, in consequence, is characterized by a relatively high mortality rate.

The third member of the group of rare obstructive hernias, representing an unusual type of internal hernia, is of particular interest academically as well as clinically.

CASE 1.*—The patient, a male aged thirty years, was admitted as an acute emergency under diagnosis of perforated duodenal ulcer. During the preceding five years he had complained of chronic indigestion accompanied by epigastric pain which usually appeared one hour after meals. Four hours before admission he developed an acute severe pain in the umbilical region accompanied by persistent vomiting. Bowels moved shortly before admission, and no blood was noted in either vomitus or stools.

On examination, the patient presented an anxious, grayish facies. The pulse rate was 68, temperature 98.6 degrees, and blood count showed 27,200 white blood cells with 96 per cent polynuclears. The abdomen was generally rigid and tender throughout and no masses were palpable. Rectal examination was negative, and there had been no bleeding per rectum.

Operation, carried out under diagnosis of perforated duodenal ulcer, disclosed a left paraduodenal hernia comprising the entire ileum, a portion of jejunum, cecum, and ascending colon. The hernial sac, as large as a human head, occupied the left gutter, and loops of black, hemorrhagic intestine could be seen through the transparent posterior peritoneal covering. On opening sac through incision over its summit, it was found that the hernia was complicated by torsion of an elongated, primitive mesentery resulting in gangrene of the distal ileum, cecum, and ascending colon (Fig. 1). This condition was treated by resection of the involved intestine, end-to-end anastomosis, replacement in retroperitoneal sac, and closure of incision through posterior peritoneum. Reduction of the hernia with obliteration of paraduodenal fossa was indicated as a concluding step, but because of patient's poor condition, this procedure was abandoned and operation concluded. Postoperative course was satisfactory, and patient was discharged at the end of the third week. This patient has been under close observation during the ensuing eleven years and since the persistence of the retroperitoneal hernia has given rise to no adverse symptoms, reoperation for the purpose of reduction of the hernia with obliteration of the paraduodenal fossa has been indefinitely postponed.

*Presented before the New York Surgical Society, November 23, 1932. Published in Ann. Surg. 97: 1935.

second, because Case 1 reported above is an example of this type of hernia. This fossa is formed just to the left of the terminal portion of the duodenum from the anterior surface of which two thin non-vascular folds pass laterally to merge with the posterior parietal peritoneum along the line of the inferior mesenteric vein. There are thus formed a superior and an inferior crescentic fold which coursing laterally become continuous with a falciform fold of posterior peritoneum raised by the inferior mesenteric behind. There is thus formed, to the left of the duodenojejunal flexure, a peritoneal pouch whose orifice looks to the right and whose anterior crescentic neck is

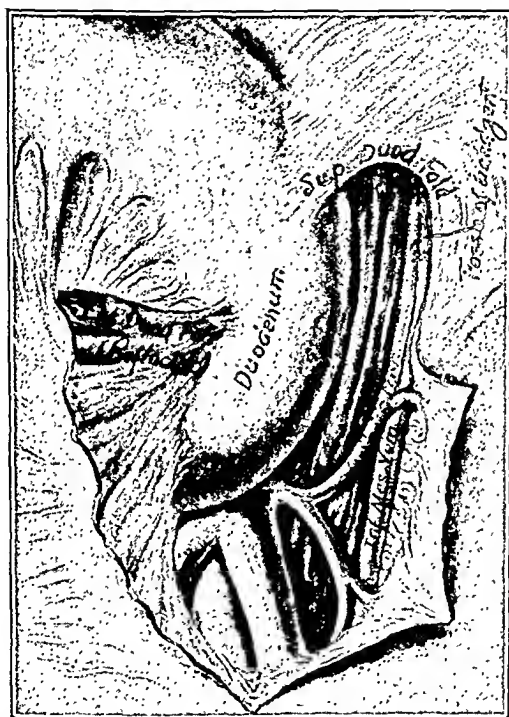


Fig. 2.—Drawing of dissection of left paraduodenal fossa. Inferior fold has been incised and reflected to show vascular relations at neck of fossa.

formed by the peritoneum-invested inferior mesenteric vein. (Fig. 2.) Herniations into this left paraduodenal fossa of Landzert insinuate themselves behind the inferior mesenteric vein and present as a true peritoneal sac in the retroperitoneal region of the left gutter.

Diagnosis in the obstructive type of left paraduodenal hernias presents obvious difficulties, and it is not remarkable that in the series cited there has been but one correct preoperative diagnosis recorded previous to 1906—that of Sherren, of London. Subsequently, in 1921, Kummer^{2A} succeeded in making a preoperative diagnosis of left paraduodenal hernia by x-ray. The symptoms parallel closely those of the obstructed

ated from the other types of internal hernias, not only by its clinical manifestations, but also by the fact that it represents a congenital anomaly.

Although Neubauer, of Leipzig, recorded in 1776 the first case of retroperitoneal hernia discovered in the course of a routine autopsy, and Landzert in 1871 for the first time described the anatomy of the paraduodenal fossae, this subject remained an academic one until 1906 when Moynihan established its status as a clinical entity and standardized the confused nomenclature and knowledge relating to this condition. He described nine different types of fossae about the duodenum in which hernia may take place and reported seventy-four examples of these hernias collected from the literature up to that time. Meanwhile a rapidly increasing number of case reports have swelled this figure so that approximately 200 cases are at this time available for study. We have recently had occasion, in another connection, to make a careful analysis of a group of these cases and were able to establish facts which have a bearing upon the present discussion of hernial obstruction. The series of paraduodenal hernias under consideration comprises 85 cases of which 59 per cent were males and 29 per cent females. The average age was 29.5 years, the youngest being aged 12 months, and the oldest 84 years. These cases were classified under two heads: (1) The silent or autopsy group which included all those instances in which the hernia was an accidental discovery during routine autopsy and in which there was no evidence that it had produced symptoms during life. In this group there were 59 cases, or 69.5 per cent of the series. (2) The acute clinical group comprising those cases treated or operated upon for symptoms incident to the presence of the hernia, or whose death, if untreated, was directly attributable to the hernia. In this group there were 25 cases, or 30.5 per cent of the series.

It is, therefore, apparent that a large percentage of the paraduodenal hernias are clinically silent, and since they do not present externally, the incidence of this condition cannot be accurately determined. It is furthermore evident that these hernias assume major clinical importance only where their benign course is complicated by some degree of incarceration or strangulation. In this latter respect, these hernias exhibit a close analogy with their external prototypes, but it is to be noted that, whereas, the incidence of these obstructive manifestations in the external hernias is less than 4 per cent, the corresponding figure for the paraduodenal hernias is 30.5 per cent.

Of the nine duodenal fossae described by Moynihan, one only—the left paraduodenal fossa of Landzert—will be considered at this time; first, because it is concerned in 70 per cent of all duodenal hernias, and

importance clinically because it is this fetal type mesentery with the wandering cecum and colon which makes possible the herniation of a large proportion of the intestinal tract as noted in Case 1.

The sac contents in the paraduodenal hernias vary from those of a few inches of the jejunum to massive inclusions of the entire small intestine with a portion of the large, as described under Case 1. Obstruction may occur in all types, but the larger hernias provide the true predisposing factors; viz., (1) a large hernial sac with comparatively small, unyielding vascular margin favoring obstruction at the neck; (2) long fetal mesentery with mobile cecum and colon predisposing to volvulus (Case 1); (3) intrasaccular adhesions leading to simple obstruction.

Although the principles governing the treatment of the external hernias (viz., [1] reduction of the hernial contents and [2] obliteration of the sac), theoretically hold good for the paraduodenal hernias, it may be recalled that the latter are clinically silent until their presence is signalized by the development of such complications as incarceration, volvulus, or strangulation, and hence when the problem of therapy arises it involves the treatment of one of these complications. The constricted neck of these hernias is a frequent site of obstruction and constitutes a major problem because the presence of important vessels in the free edge of the neck contraindicate incision of the constriction at this point. Under these conditions, opening the sac itself will frequently permit a retrograde reduction of the contents, and this same maneuver is indicated in case of volvulus, incarceration, or strangulation within the sac, and particularly when resections of gangrenous intestine become necessary. Partial excision of the sac, obliteration of the cavity by suture, or closure of the orifice are advisable after reduction of the hernial contents, due consideration being given to the proximity of important neighboring vessels. These patients are usually received in some degree of shock and an operative mortality rate exceeding 50 per cent was recorded in some of the early series. In the meantime, the modern policy of prompt intervention in cases presenting symptoms of intestinal obstruction has gradually reduced this rate so that it now approximates the figure which obtains for cases of intestinal obstruction in general.

There were three instances of partial enterocoele (Richter's hernia) recorded in the series of 130 cases of obstructive hernias. The first instance complicated a femoral hernia in a female of fifty-five years of age and involved a portion of the wall of the ileum in a gangrenous process requiring resection. The second case occurred in a female of forty-one years of age in conjunction with a ventral hernia. Reduction was accomplished without the necessity of resection. The third

external hernias except that they are not associated with or identified by the usual external hernial mass. A large proportion of cases give a history of recurrent attacks of indigestion associated with occasional attacks of epigastric pain and marked constipation, which may be intermittently replaced by periods of diarrhea, all of which express varying degrees of incarceration or partial obstruction. With the onset of complete obstruction, two very significant signs appear in more than 50 per cent of the cases, and when observed in conjunction with the above history, should establish the diagnosis. The first is due to the presence of the large retroperitoneal hernial mass which appears in the mesogastrium slightly to the left as a smooth, cystlike, globular tumor, varying in size from that of a grapefruit to an adult head. This mass is somewhat movable, yields a tympanitic note on percussion, and on auscultation over it, clear intestinal sounds can be heard. The second diagnostic sign results from a combination of mechanical and anatomic factors at the orifice of the paraduodenal fossa which becomes the constricted neck of the hernial sac. As the hernia increases in size, the thin crescentic margin of this orifice is exposed to the effects of stretching and dragging by the massive sac contents, so that the inferior mesenteric vein coursing along the sharp anterior margin of the constricted neck suffers a degree of compression which produces mechanical stasis and back pressure in the inferior mesenteric venous system, and this is expressed clinically by the acute development of large internal hemorrhoids or bleeding from the lower bowel. It seems justifiable to conclude, therefore, that a preoperative diagnosis of paraduodenal hernia should be made with a reasonable degree of certainty when the clinical evidences of acute intestinal obstruction are associated with the presence of a large, globular mass in the left mesogastrium and accompanied by lower bowel hemorrhage.

Space will not permit a consideration of the etiology of these hernias, but it may be stated that the theory of congenital origin of the paraduodenal fossae and associated phenomena is well supported. During the conversion of the embryonal status of the gastrointestinal tract, characterized by the primitive dorsal mesentery, into its permanent adult relation, the cecum migrates upward from its left lower abdominal position toward the left upper abdomen, then progresses across the epigastrium to eventually become fixed by fusion of fetal mesenteries in the right lower quadrant. It seems quite clear that congenital anomalies, such as the fossae about the duodenum and the persistence of fetal mesenteries, represent the failure of the peritoneum to properly adjust itself during this process. It is interesting to note the frequency with which the fetal type of mesentery with mobile cecum or colon and incomplete rotation of the large intestine are reported in conjunction with retroperitoneal hernias. This fact is of

third decades so that, if the incidence of obstruction in this group remains consistently proportional, its curve should roughly parallel the curve of frequency.

Chart II compares the age incidence in both sexes and brings out the facts that (1) the high incidence of obstruction in the first decade takes place in the male sex, (2) that hernial obstruction in the female sex is extremely rare before the third decade, and (3) that after the second decade the incidence curves of hernial obstruction in the two sexes run roughly parallel courses.

Complications, such as incarceration and strangulation, arising during the first decade present special features which distinguish them from the analogous adult condition. These complications are undoubtedly

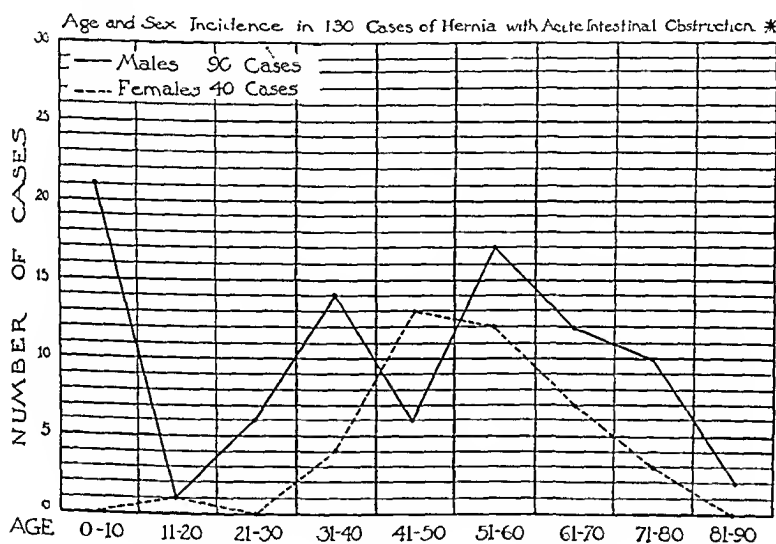


Chart II.—Comparison of the age incidence of hernial obstruction in both sexes.

edly most common in the first year and are probably related to attempts at natural closure. The small irreducible hernias are more dangerous than the larger types because they are most often associated with circulatory disturbances. Irreducibility is, however, particularly innocuous to children, and even with intestine in the sac, obstructive symptoms are infrequent. The rarity of true strangulation at this period of life is confirmed by the investigations of Estoei³ who showed that among 139,000 hernias in children there was not a single herniotomy done for strangulation. Fraser⁴ found in an analysis of 10,000 cases at the Edinburgh Children's Hospital that there was no instance of complete strangulation and gangrene such as is seen in adults. Out of the total series, there were fourteen cases of irreducible hernia in which there was sufficient interference with blood supply to justify the qualification of strangulation, and in these extreme in-

instance was observed in a male of sixty years of age in whom a knuckle of ileum became involved in a recurrent inguinal hernia. The obstructed loop was freed through a right rectus incision and returned to the abdomen without resection. In all three cases the obstruction was complete and of less than three days' duration. There were no deaths in this group.

Chart I records by decades the age incidence in 130 cases of acute intestinal obstruction due to hernia and graphically emphasizes the exceptionally high incidence of this condition in the first ten years of life (21, or 16.1 per cent of the cases) with an abrupt fall in the second decade, followed by a gradual rise to a maximum (30, or 23 per cent

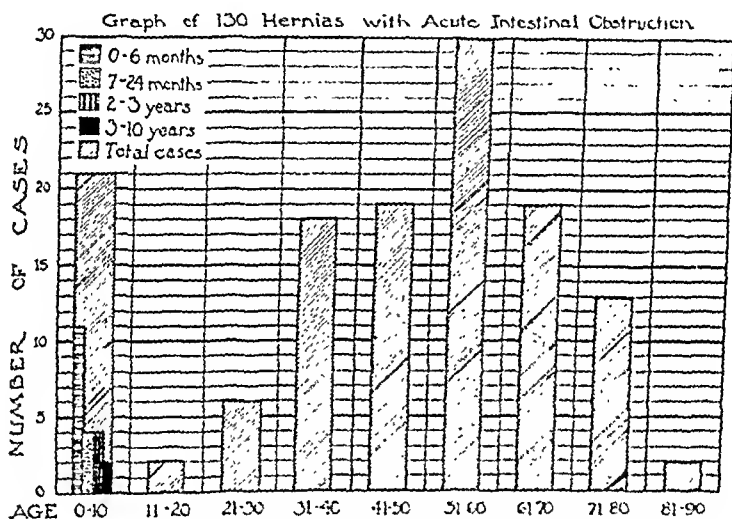


Chart I.—Age incidence by decades in 130 hernial obstructions with insert graph analyzing cases occurring in the first decade.

of the cases) in the sixth decade. The insert graph in the first decade is of particular significance and indicates that of the cases noted during this period, 11, or 52.3 per cent, occurred during the first six months of life; 15, or 71.4 per cent, took place before the second year; and 19, or 94.2 per cent, before the third year. The unusually high incidence of hernial obstruction noted in the first decade has usually been explained on a basis of certain anatomic and mechanical factors peculiar to children, but in our opinion this incidence merely expresses the conventional ratio of obstructive complications to be anticipated in a decade which boasts of the greatest hernial frequency. In a study of 10,000 hernias, Berger² showed graphically that 75 per cent of hernias made their appearance during the first decade, after which the curve of frequency fell sharply through the second and

fall in blood pressure and which is followed by an accumulation of blood in the large veins. Others hold to the theory that shock is associated with constriction of the arterioles which expresses plasma from the blood stream and in this manner brings about a decrease in the volume of circulating fluid. Cannon⁵ believed that the persistent fall of blood pressure following trauma was due to the liberation by the traumatized tissue of a histamine-like depressant. Blalock and Bradburn,⁶ working with dogs, observed that the oxygen content of blood from the femoral vein in traumatized extremities was consistently higher than the controls and suggested that a local accumulation of blood occurs in the traumatized area. Subsequently, Blalock⁷ estimated the blood loss in traumatized areas and presented evidence which indicated that the low blood pressure noted after trauma to the extremity of an experimental animal is due to loss of blood into this traumatized area. Finally, this same observer,⁸ noting that prolonged trauma to the intestinal tract resulted in a marked decline of blood pressure, studied in the same manner the effect of trauma upon the intestines and concluded that the loss of fluids from and into the traumatized intestinal segment was the chief cause for the reduction in pressure observed in these instances.

Among our cases of hernial obstruction, there were twenty-one instances in which varying degrees of shock were observed, and it is our conviction, based upon these observations, that clinically at least this condition differs in no important respect from the type of shock seen in severe trauma. As to the mechanism of its causation in hernial obstruction, it may be pointed out that incarceration or strangulation of an intestinal loop is associated with a degree of prolonged trauma; and it is tempting to assume, in the light of experimental evidence, that the consequent loss of fluid into and about the traumatized loop due to hemorrhage, capillary engorgement, and filtration of plasma is sufficient to produce the typical fall in blood pressure and shock.

TREATMENT

In reference to treatment, it is important to recognize that fundamentally hernial obstruction presents two problems for solution; the first, provided by the obstructed intestine, is local and primary; while the second, expressed in the form of constitutional effects of the obstruction, is general and secondary. To meet the first problem three possible indications are to be considered: (1) relief of obstruction; (2) treatment of the strangulated hernial contents; (3) repair of the hernia. Relief of obstruction is the primary purpose of operation; it is frequently a lifesaving measure and is occasionally the only step permissible where severe shock exists. Under these conditions opera-

stances the vascular changes were limited to patches of necrosis. Analysis of our own series of obstructive hernias occurring in the first three years shows that all were males, all had inguinal types of hernia, thirteen were obstructed at the external ring and five at the internal, while the small gut was involved in thirteen instances and the large in four. There was no instance in which gangrenous intestine required surgical attention; there were no deaths; and the average duration of obstruction was less than twenty-four hours. This last figure, compared with the average duration of obstruction in the series of 130 cases of all types and ages, suggests that the rarity of true strangulation in children is due less to anatomic and mechanical factors and more to the spirit of promptness which brings these children to early operation.

In general, the symptoms induced by hernial obstruction were conventional and require little comment. An acute onset of pain associated in the external hernia, with an enlarged, tense, irreducible, and sometimes inflamed hernial mass, was quite constant. Nausea, vomiting, and constipation were usually observed, but distention and other abdominal evidences of obstruction were as a rule conspicuously absent due to the infrequency of low gut obstruction. Temperatures, with few exceptions, were normal or subnormal and white blood counts presented, in most instances, normal or very slightly elevated figures.

Of greatest significance in the clinical picture is the appearance of a condition called shock characterized by an ashy pallor, cold clammy skin, a rapid pulse of small volume, and hypotension. This condition was most commonly observed in elderly patients with prolonged obstruction, but it was not infrequently noted also in relatively young subjects whose hernias had come down for the first time and in whom the obstruction was of short duration. In three instances this type of shock induced a moribund state which precluded operation and led to a mortality in each case, while among the 38 deaths which occurred among the patients operated upon, 39 per cent were ascribed to this cause.

This same shock syndrome, which is recognized as an important feature in severe trauma generally, has attracted the interest of many able investigators and many divergent theories have been advanced to account for it. At the present time there is quite general agreement that diminution of the circulating blood volume is an essential part of the shock picture, but there is a wide difference of opinion as to the cause of this diminution. Crile and his associates maintain that prolonged sensory stimulation flowing from the traumatized regions produces exhaustion of the vasomotor center which leads first to a

of shock, a lower operative mortality, a limitation of progressive tissue destruction, and a decreased incidence of resection or enterostomy. On the other hand, hasty operation in advanced cases, complicated by typical shock, imposes a major surgical procedure upon a patient already overburdened by dehydration from fluid loss, distorted blood chemical values, gastrointestinal ileus, etc., and when disregarded pre-operatively, these latter factors account for a considerable proportion of the surgical deaths.

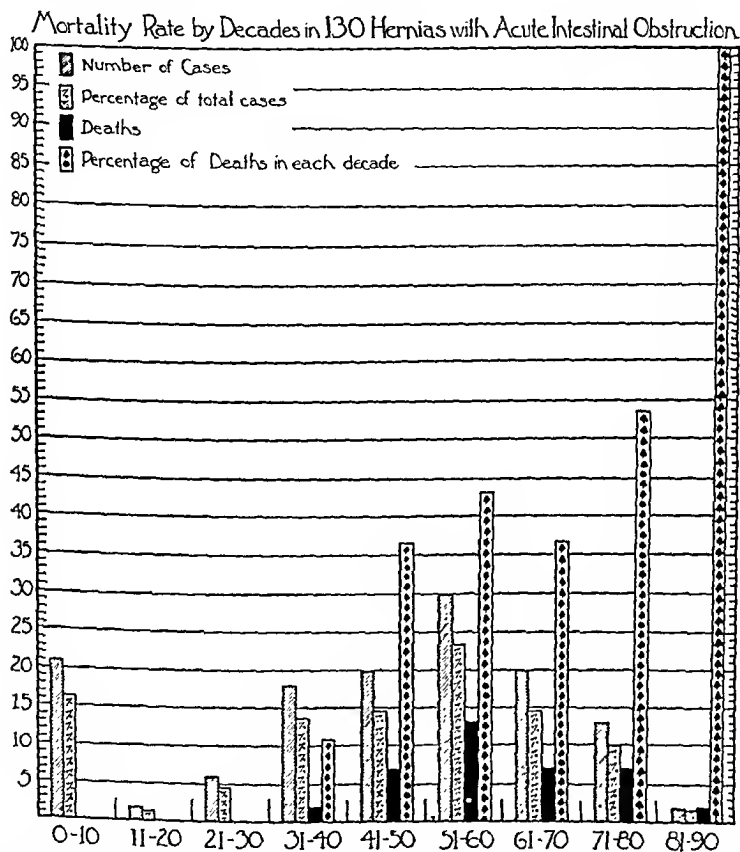


Chart III.—Graphic analysis by decades of the 38 deaths occurring among 130 hernial obstructions to show distribution and percentage distribution of deaths in relation to total number of cases.

Thus the ideal attack upon the constitutional phase of this problem suggests itself; viz., that regardless of the degree of local damage or the duration of obstruction, operation should await a preliminary period devoted to restitution, so far as possible, of perverted chemical and physiologic processes. Shock and dehydration being characterized fundamentally by diminution of circulating fluids, the first indication is the restoration of these fluids in a form which will remain longest in the vascular tree. Whole blood best meets this indication

tive procedure is limited to simple incision of the constriction combined with enterostomy *in situ* or with exteriorization plus enterostomy in those instances in which severe intestinal damage or ileus indicate the need of decompression and subsequent repair of intestine. Treatment of the hernial contents, the next indication, is second in importance only to the relief of obstruction and is reserved for those patients whose condition will tolerate more extensive procedures. At this point, decisions must often be made which tax the judgment of the most experienced operator—choice between reduction, exteriorization, and resection; determination of type of anastomosis; estimate of the patient as a surgical risk; etc. Each problem must be individually evaluated upon its own merits and only general, well-recognized principles can be laid down. Dark, congested, or even purplish gut whose serosa retains its normal gloss may usually be reduced without fear; whereas, the loss of this sheen with persistence of black discoloration after release usually indicates the necessity for resection. In the small gut, the aseptic type of end-to-end anastomosis is to be preferred; in large gut resection the side-to-side method is undoubtedly the safest; and in both a proximal catheter enterostomy should invariably be added for decompression. Prolonged stasis with ileus and dilatation may contraindicate primary anastomosis in some cases and some form of decompression-excision procedure on the Mikulicz principle may be required. In children, resection is accompanied by a high mortality and is to be employed only where indications are positive and definite. On the other hand, palliative enterostomy is poorly tolerated in early life and immediate resection is preferable to enterostomy.

Among our series of 130 cases of hernial obstruction, 13 cases had primary resections and of these 6, or 46.2 per cent, recovered, while 7, or 53.8 per cent, died. Of the latter, 6, or 85.5 per cent, were in femoral hernias whose contents in every instance was small gut. The anastomosis was of the end-to-end type in 4 of these cases and side-to-side in 2 cases. Exteriorization was employed in 7 cases with 6 deaths and 1 recovery.

In respect to the second fundamental problem—the constitutional effects induced by obstruction—we are convinced from a critical analysis of our deaths, that among our early cases this factor was improperly evaluated and that ill-advised haste has contributed materially to mortality rates. Subsequent experience has led to the paradoxical conclusion that the early obstructions are the logical operative emergencies, while the advanced cases admitted in shock merit delay provided that this period of delay is properly utilized. In other words, early operations on obstructions of short duration mean a minimum degree

3. Although hernial obstruction shows a high incidence in the first decade, and 94.2 per cent occur before the third year, there was no single instance in which resection of gut was required.

4. Early operation and release of obstruction constitute the primary objectives of surgical treatment.

5. Shock is the most serious complication of hernial obstruction, 39 per cent of deaths being ascribed to this cause alone.

6. The mortality rate in 13 primary resections was 53.8 per cent while 7 exteriorizations showed a mortality rate of 85.7 per cent.

7. The average age for the series was 44.1 years, while the average age in 38 cases which died was 60.2 years.

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and our preference at this time is for its administration by the citrate method. Gum acucin solution, when properly prepared, glucose and saline solution, or normal saline solution alone, are of considerable value in correcting distorted blood chemical values, raising blood pressure, and replacing fluid loss, but they are all of secondary choice because of their transitory effect. They are, therefore, best given in massive amounts by slow, intravenous drip. Decompression of the gastrointestinal tract is of equal importance as a preoperative measure in the presence of distention and vomiting, and the suction-siphonage method devised by Wangensteen⁸ plays an extremely important rôle in this as well as in the postoperative period.

The treatment of the hernia in hernial obstruction requires little comment since it plays a small part in the problem after the obstruction has been relieved and the hernial contents cared for. In obstructions associated with gut damage, its repair must obviously be postponed, and even in those early cases where the damage has been minimal, ideal repair must be attempted with caution since it has been shown¹⁰ that in strangulated hernias a grossly intact intestine may be permeable to bacteria which may frequently be cultured from the sac fluid.

As previously noted, there were 38 deaths in this series establishing the mortality rate of 29.2 per cent. Chart III analyzes this group by decades and shows that, beginning with the fourth decade, the actual number of deaths rose gradually to reach a maximum in the sixth decade, while the percentage death rate shows a gradual rise from the fourth to the ninth decade where it reaches its maximum. Of the 38 deaths, 35 were operative and 3 died without operation. Twenty of these cases were males and 18 were females. Femoral hernia led the list as a cause of death with 15 cases; inguinal hernia was second with 13 cases, and all other types combined numbered 10. The immediate cause of death was ascribed to shock in 15 cases (39 per cent) of this group; to pulmonary complications in 8 cases; to cardiocirculatory failure in 5 cases; to peritonitis in 2 cases; and to miscellaneous factors in 8 cases. The average age of the patients who died was 60.2 years.

In conclusion, we may briefly summarize the results of our study of 130 cases of hernial obstruction as follows:

1. Hernia, inclusive of all types, comprises 6.5 per cent of all general surgical hospital admissions; 4 per cent of hernias are at some time or other complicated by obstruction; and this 4 per cent is responsible for 54 per cent of intestinal obstruction from all causes.

2. Obstruction due to femoral hernia shows the highest figure for average age of onset, duration of symptoms, and mortality, while indirect inguinal shows the lowest.

to locate the appendix and the ileocecal junction. The appendix was finally found, pointing downward into the pelvis and covered by a greatly distended, plum-colored intestine, which proved to be the cecum. The appendix was gradually brought upward and seen to be moderately injected. At the same time it was noted that the cecum itself rotated, or turned, to a more normal position. The distention disappeared, and the small intestine that had been previously collapsed became moderately distended. Simultaneously the discoloration of all the intestines appeared to clear up with a restoration of the circulation. The torsion was apparently in a counterclockwise direction. After release, it was noted that the cecum and terminal ileum were attached by a long common mesentery, which allowed great latitude of movement.

After removal of the appendix in the usual manner and inversion of the stump, it was possible to demonstrate that the ileocecal junction was in an unusual position.

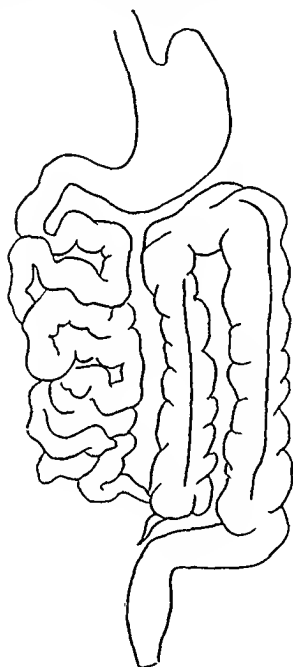


Fig. 1.—Schematic drawing indicating unusual ileocecal relations and sinistroposition of the colon as demonstrated both at operation and subsequent x-ray examinations.

tion. The small intestine extended from above at the right side of the abdomen to unite with the cecum below and to the left. Further investigation showed that the entire large intestine was also on the left side of the abdomen, as in the accompanying diagram (Fig. 1). As no further procedure seemed advisable at the time, the abdomen was closed without drainage.

The patient made an uneventful recovery, at no time during his stay in the hospital complaining of the pain which had caused him to seek admission. He was discharged on the twelfth postoperative day.

Before discharge, a barium enema was given by I. Schwartz, with the following findings: August 19, 1936: All of the colon visualized was found in the left of the abdomen. At the splenic flexure, several redundant loops of colon were visualized, lying below and to the left of the flexure. One loop of gut was traced downward

INCIPIENT VOLVULUS OF THE CECUM ASSOCIATED WITH LEFT-SIDED COLON

REPORT OF CASE, WITH NEW X-RAY SIGN OBTAINED BY BARIUM ENEMA

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AUTHORITIES agree that a torsion of the intestine on its mesenteric axis must be of at least 180 degrees to constitute a volvulus, since pathologic changes rarely begin before that stage is reached. However, in the course of an exploratory laparotomy, one sometimes encounters a condition that may be regarded as an initial stage of volvulus; i.e., a twist of less than 180 degrees. Such a discovery is comparatively rare, and as very little can be found in the literature regarding this condition, the following case may be of interest as a typical illustration:

CASE REPORT.—T. C., white, male, twenty-six years old, electrician's helper. Admitted to Knickerbocker Hospital August 8, 1936, complaining of pains in the lower abdomen, of three hours' duration, accompanied by vomiting.

The patient had taken a bottle of citrate of magnesia several hours before onset to relieve constipation, and this had produced two good bowel movements. The pains, which were of a very severe, colicky nature, were more pronounced on the right side, but did not radiate. Sitting up or coughing increased the pain, but other movements had no effect. Patient had vomited food and greenish material twice in the past hour without relief.

Three months ago the patient suffered a similar attack, but without vomiting. The pain lasted for some three hours and then cleared up spontaneously.

Physical examination was essentially negative, except for the abdomen. Breathing was costal in type. There was a generalized moderate rigidity, most pronounced in the right lower quadrant. Tenderness on deep palpation over both lower quadrants, reaching its maximum over McBurney's point, and slight rebound tenderness in the right lower quadrant. There were no masses, and no distention was apparent. Resistance in both flanks, but no tenderness. Rectal examination negative. Soon after admission the patient vomited again, the vomitus consisting of an intestinal content typical of the early stages of obstruction.

Blood count showed 11,800 white blood cells; 78 per cent polymorphonuclears; hemoglobin, 98 per cent. Urine negative. Temperature and pulse were only slightly above normal.

The impression was one of acute appendicitis, or possibly a perforated peptic ulcer. Two and a half hours after admission an exploratory laparotomy was done under ether anesthesia.

Operation.—McBurney incision. On opening the peritoneum, a moderate amount of free, clear serous fluid was found. No ascending colon or cecum was seen in the normal position. Several loops of small intestine were encountered, which were for the most part collapsed. The incision was then prolonged downward in order

Second Admission.—Since his discharge on August 20, the patient had been troubled with chronic constipation. Bowels had been moved regularly with mineral oil. The day before admission, October 6, he noticed dull pains in the lower abdomen, which gradually increased. Vomiting began two or three hours later and had continued intermittently. The morning of admission he suffered a violent attack of colicky pain, which he said was the same as he experienced prior to his first admission. The pain did not radiate. He had a good bowel movement the day before but none on the day of admission.

Abdominal examination was essentially negative, except for an indefinite mass in the suprapubic region. No visible peristalsis; no localized tenderness or rigidity; no distention. Patient catheterized after voiding, but no urine obtained. High colonic irrigation resulted in the passage of a few fecal particles and some flatus and diminished the circumference of the abdomen 1 cm. Temperature, 98; pulse, 72; respiration, 18. Blood count, 10,000 white blood cells; 88 per cent polymorphonuclears.

After careful consideration, it was decided that no immediate surgical intervention was indicated until further x-ray study by means of barium enema could be made. This was done on October 8, with meager results. The column of barium was not seen to reach beyond the portion of the large intestine corresponding to the transverse colon. Considerable gas appeared distributed in the right lower quadrant and suprapubic region of the abdomen in a hollow viscus which suggested by its conformation part of the large intestine (ascending colon and cecum) (Fig. 2). No great distress was evident following the barium enema, and the patient slept comfortably all night. He was examined the next morning by several members of the staff, and the roentgenograms were considered. It was decided that there was still no indication for an emergency operation. Vomiting continued intermittently. Clyses were given and Wangensteen suction siphonage afforded relief.

On the morning of October 9, a soapsuds enema produced a considerable return of barium. No change was noted in the abdomen at any time during the day. In discussion of the case at a staff conference, perforation seemed an unlikely contingency, and plans were made for an operation of choice, preferably a cecopexy.

A 5:30 A.M. on October 10, however, the patient was awakened by a sharp generalized pain followed by vomiting. The pain was particularly marked about the navel. The abdomen became boardlike throughout and tympanic. Liver dullness was partially obliterated. Temperature, 103.4° F.; respiration, 36; pulse, 132; blood count, 7,500 white blood cells; 93 per cent polymorphonuclears. Impression: rupture of a viscus, probably due to volvulus with gangrene.

Operation was begun at 8:00 A.M. *Findings:* The peritoneum was darkened, and when opened a large amount of foul-smelling gas escaped. The peritoneal cavity was loaded with liquid fecal matter and barium. The caput coli presenting in the wound was dilated. This collapsed and a clockwise torsion of the segment of more than 180 degrees became apparent. In reducing this torsion, a gangrenous area 7 or 8 cm. in diameter on the right lateral and anterior aspect of the cecum, about 4 cm. distal to the ileocecal junction, was uncovered. At its center there was a perforation approximately 1½ cm. in diameter.

Procedure.—Lower midline incision of 15 cm. Fecal matter and barium suctioned out and removed with wet sponges. Perforation temporarily closed with curved hemostat. Gangrenous area of cecum exteriorized, and healthy cecal edges sutured to the edges of the peritoneum. Penrose drain inserted into pelvis and wound left open. Continuous intravenous infusion of glucose and saline started.

The operation took twenty minutes, but as the patient was already in shock, with a weak, thready pulse, he did not rally. During the day the infusion was con-

to the midline from the region of the splenic flexure. Its terminal portion was concealed by overlying loops of sigmoid. After expulsion of part of this barium, the x-ray appearance did not change appreciably. Twenty-four hours later, no spontaneous bowel movement having occurred, a soap-suds enema was administered and all the barium expelled from the colon.

Ten days later, following the patient's discharge from the hospital, a gastrointestinal series confirmed the above findings. Neither fluoroscopic examination nor roentgenogram revealed any abnormality of the duodenum, and as this organ was not explored at the time of operation, it was not known whether it had a distinct mesentery such as might be expected with nonrotation of the colon.

The findings in this case of a left-sided colon and a volvulus of the cecum in an initial stage of less than 180 degrees were both so unusual as to suggest a search of the literature to see if any similar cases had been recorded. The nearest parallel discovered is that reported by Fécan,¹ as follows:

A woman of twenty-one years of age had been troubled with intermittent digestive disturbances for two or three years. She had nausea, vomiting, and habitual constipation but had never suffered an acute attack of appendicitis. Repeated physical examinations failed to reveal any masses. To verify a tentative diagnosis of chronic appendicitis, a radiographic examination was made, which disclosed a transposition of the large intestine to the left of the median line and at the same time an abnormal development of one loop of the sigmoid. It could not be determined, however, precisely where the internal border of the cecum was, or if it was diseased. Only one thing seemed clear—that the point of tenderness of the right iliac fossa was not due to the appendix.

A barium enema two days later showed exactly the same abnormal topography of the large intestine. One could see filling up immediately an enormous sigmoid loop, which extended up into the abdomen to the level of the second lumbar vertebra. Instead of being stretched out at length, as is usual in similar cases, it was turned at an acute angle to the left of the median line. Next, at the left of this double gunbarrel, the descending colon filled in its turn, became dilated, and the splenic flexure was visible in its usual position. At last, a fourth segment filled up, at the right of the sigmoid loop this time, very oblique below and at the right, extending considerably beyond the median line because of the distention. It showed the transverse and ascending colons, their angle being almost obliterated. The cecum was superimposed on the rectum and on account of the sigmoid loop could not be seen very distinctly. After the injection of at least 1 and $\frac{1}{2}$ liters of opaque liquid, four great shadows could be seen juxtaposed from right to left, leaving the right iliac fossa transparent. Thus two angles were delineated, one in the other, that of the sigmoid loop on the inside and that of the colon on the outside.

The examination of this patient relieved her of the incomplete torsion of the intestine.

Since, in our case, the patient had no recurrence of symptoms for seven weeks and was apparently cured, it was believed that the simple untwisting of the partial torsion had brought the same happy results as in Fécan's case. However, on October 7 a sudden flare-up occurred, and the patient was readmitted to the hospital.

Second Admission.—Since his discharge on August 20, the patient had been troubled with chronic constipation. Bowels had been moved regularly with mineral oil. The day before admission, October 6, he noticed dull pains in the lower abdomen, which gradually increased. Vomiting began two or three hours later and had continued intermittently. The morning of admission he suffered a violent attack of colicky pain, which he said was the same as he experienced prior to his first admission. The pain did not radiate. He had a good bowel movement the day before but none on the day of admission.

Abdominal examination was essentially negative, except for an indefinite mass in the suprapubic region. No visible peristalsis; no localized tenderness or rigidity; no distention. Patient catheterized after voiding, but no urine obtained. High colonic irrigation resulted in the passage of a few fecal particles and some flatus and diminished the circumference of the abdomen 1 cm. Temperature, 98; pulse, 72; respiration, 18. Blood count, 10,000 white blood cells; 88 per cent polymorphonuclears.

After careful consideration, it was decided that no immediate surgical intervention was indicated until further x-ray study by means of barium enema could be made. This was done on October 8, with meager results. The column of barium was not seen to reach beyond the portion of the large intestine corresponding to the transverse colon. Considerable gas appeared distributed in the right lower quadrant and suprapubic region of the abdomen in a hollow viscus which suggested by its conformation part of the large intestine (ascending colon and cecum) (Fig. 2). No great distress was evident following the barium enema, and the patient slept comfortably all night. He was examined the next morning by several members of the staff, and the roentgenograms were considered. It was decided that there was still no indication for an emergency operation. Vomiting continued intermittently. Clyses were given and Wangensteen suction siphonage afforded relief.

On the morning of October 9, a soapsuds enema produced a considerable return of barium. No change was noted in the abdomen at any time during the day. In discussion of the case at a staff conference, perforation seemed an unlikely contingency, and plans were made for an operation of choice, preferably a cecopexy.

A 5:30 A.M. on October 10, however, the patient was awakened by a sharp generalized pain followed by vomiting. The pain was particularly marked about the navel. The abdomen became boardlike throughout and tympanic. Liver dullness was partially obliterated. Temperature, 103.4° F.; respiration, 36; pulse, 132; blood count, 7,500 white blood cells; 93 per cent polymorphonuclears. Impression: rupture of a viscus, probably due to volvulus with gangrene.

Operation was begun at 8:00 A.M. *Findings:* The peritoneum was darkened, and when opened a large amount of foul-smelling gas escaped. The peritoneal cavity was loaded with liquid fecal matter and barium. The caput coli presenting in the wound was dilated. This collapsed and a clockwise torsion of the segment of more than 180 degrees became apparent. In reducing this torsion, a gangrenous area 7 or 8 cm. in diameter on the right lateral and anterior aspect of the cecum, about 4 cm. distal to the ileocecal junction, was uncovered. At its center there was a perforation approximately 1½ cm. in diameter.

Procedure.—Lower midline incision of 15 cm. Fecal matter and barium suctioned out and removed with wet sponges. Perforation temporarily closed with curved hemostat. Gangrenous area of cecum exteriorized, and healthy cecal edges sutured to the edges of the peritoneum. Penrose drain inserted into pelvis and wound left open. Continuous intravenous infusion of glucose and saline started.

The operation took twenty minutes, but as the patient was already in shock, with a weak, thready pulse, he did not rally. During the day the infusion was con-

finned, forty drops per minute, and coramine and digalen injections were given, together with an adequate amount of morphine. Despite all these measures, the temperature continued to rise to 107.6° ; and at 2:00 A.M. on October 11, the patient expired.

A partial postmortem examination of the wound was made by Adams, with the following findings:



A.

Fig. 2.—A, Barium enema five minutes after injection, showing the splenic flexure as a fixed point at the top and the blocking of the column of barium somewhat lower to the right; also large gas bubble showing site of the volvulus. B, Barium enema four hours after administration, showing gas bubble even larger than in A, and typical conformation of the large intestine.

Postmortem.—There was about 500 c.c. of dark fluid having a fecal odor in the peritoneal cavity. There were numerous fresh adhesions about the intestines. The cecum was dilated to twice its normal size, and there was a circumscribed area of gangrene on its anterior surface about 8 cm. in diameter, in the center of which was a perforation about the size of a nickel. A markedly elongated common

mesentery was attached to the cecum and terminal ileum, allowing a wide range of movement to both structures. The terminal ileum entered the cecum from the right. About $1\frac{1}{2}$ feet from the ileocecal junction, there was an old adhesion of the terminal ileum to the parietal peritoneum on the lateral abdominal wall covering the right iliac fossa. The ileum was twisted upon itself at this point.



Fig. 2B.—(See opposite page for legend.)

The stomach and duodenum were apparently normal, although the latter appeared to be somewhat more freely movable than usual. Whether a mesentery was attached to the duodenum could not be made out. There was no structure suggestive of a greater omentum.

The ascending colon was located approximately in the midline, running upward to about the level of the inferior border of the stomach, where it was fixed firmly to the posterior abdominal wall. The intestine was somewhat constricted at this point. It then ran diagonally to the left upper quadrant to form the splenic flexure. The descending colon and sigmoid were normal in appearance, course, and relations.

This is a case in which a few comments after the unfortunate event may serve as forewarnings to other surgeons confronted with a similar situation:

The recurrence of the same typical colicky pain as on the first admission should have constituted a definite warning that volvulus was present. This probability was thoroughly considered by the writers and other members of the surgical staff, but since the patient's symptoms were more or less chronic, it seemed advisable at the time to form a definite plan for the relief of his condition based on the results of another barium enema. In the meantime, the temperature, pulse, respiration, and blood count were so nearly normal as to lull one into a sense of security regarding any impending catastrophe, such as gangrene or perforation.

The barium enema itself evidently did not have the beneficial effect noted in the case reported by Fécan, but on the other hand it may not have greatly aggravated the situation. The findings at operation and autopsy would seem to indicate that an impaired circulation of the cecum supervened at some time between the patient's admission to the hospital on October 7 and the onset of his acute symptoms at 5:30 A.M., October 10. Whether this was entirely due to the incipient volvulus or partly to the anomalous blood supply of the cecum, whereby one of the terminal blood vessels became twisted and occluded as a result of torsion of the intestine and adhesion of the terminal ileum, is impossible to determine. It seems perfectly clear that only one such blood vessel was affected, as the area of gangrene was definitely demarcated and the perforation occurred at its center.

In view of the operative findings, it is necessary to review the meager results of the barium enema administered on the second admission. Quite evidently there was an obstruction to the flow of barium into the cecum, due to the torsion of the intestine, and the x-ray revealed a distended cecum with a large gas bubble in the hypogastrium and somewhat to the right of the portion of the intestine at which the column of barium was blocked in its progress. The significance of this finding was not entirely lost upon the writers, and now, in the light of the subsequent catastrophe, it seems to have been the final indication that operation should not have been delayed.

CONCLUSIONS

The finding of a volvulus of the cecum in its initial stages, with a clearing up of symptoms on simple untwisting, appears to be sufficiently unusual to prompt a report of the case. A rather extensive review of the literature had brought to light only two similar instances: the one recorded by Fécan¹ and another by Negroni.²

In our case, no attempt was made at the time of operation to correct the malposition of this freely movable segment of intestine because of the acute symptoms then prevailing. There followed an interval of about seven weeks during which the patient was free from symptoms, other than chronic constipation. Then a flare-up occurred, accompanied by an ill-defined mass in the suprapubic region. While investigation was being made to determine a more definitive method of surgical interference, conservative treatment resulted in gangrene and perforation, from which the patient died.

Sign.—The authors believe that a new diagnostic sign of great importance has been established for volvulus of the cecum: When in the course of a barium enema, the column of barium is unable to pass beyond a certain point in the region distal to the cecum; i.e., in the ascending or transverse colon (organic lesions being excluded) so that the cecum itself cannot be properly delineated in its haustral markings by the barium, and when at the same time a large collection of gas appears at the site of the cecum indicating its patency and conformation, either in the midline or slightly to the right of it, as in Fig. 2, this is a clear sign that volvulus of the cecum has taken place and is a definite indication for emergency operation.

Holubec³ reported confirmation of a diagnosis of cecal volvulus by means of a lateral x-ray view, but in our case it is questionable whether the lateral view, taken before the barium enema, would have given similar results.

In view of this experience, the authors believe that any known case of nonrotation of the large intestine with similar indications should have immediate surgical intervention, with an operative procedure designed to fix the loose segment involved.

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PANCREATIC JUICE AS A FACTOR IN THE ETIOLOGY OF GALLBLADDER DISEASE

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IN STUDYING the literature on the subject of the etiology of gallbladder disease, only a few references are to be found, chiefly in the German, which deal with pancreatic juice as a possible factor. In contrast, it is the consensus of opinion that bile plays a distinct rôle in the causation of acute pancreatic necrosis. As one analyzes the latter postulation (i.e., that bile can be forced into the pancreatic duct and due to its action upon the pancreatic juice, or the pancreas itself, produce varying types of pancreatic disease), it would seem equally possible, or even probable, that pancreatic juice may enter the biliary ducts, and since the action of pancreatic juice may, under condition of activation, be very corrosive, lead to destructive changes in the biliary system. Therefore it may be pertinent to analyze further the problem with a view to clearing the hypothesis that pancreatic juice may be a factor to be considered in the etiology of gallbladder disease.

EMBRYOLOGIC CONSIDERATIONS

The liver with its ducts arises, in embryo, from a budlike projection of the main gastrointestinal stem. This diverticulum appears very early as a small budlike knob. The hepatic duct, including the larger intrahepatic ducts which secondarily grow and subdivide from it, and the ductus choledochus are the stem portions of the original hepatic diverticulum; the gallbladder and its cystic duct represent a special offshoot of the early diverticulum. The pancreas arises from two buds, the dorsal and the ventral. The smaller, or ventral, bud appears in the caudal angle between the gut and the liver diverticulum. Often this ventral pancreatic bud comes off directly from the hepatic tube, and as the common duct lengthens, it carries away with it the duct of that portion of the pancreas. (Fig. 1.) The dorsal and larger bud arises on the dorsal side of the gastrointestinal stem at a slightly higher level. With rotation of the gastrointestinal stem the smaller, or ventral, portion of the pancreas will be found lying adjacent to and inferior to the larger dorsal portion. Fusion of the two parts takes place while the duct of the dorsal pancreas is still the major duct. After fusion of the two portions of the pancreas, the ducts become connected, the ventral duct becoming the larger, the duct of Wirsung, while the dorsal atrophies to form the duct of Santorini. (Fig. 2.) This embryologic development forms the

basis of reasoning relatively to adult anatomic arrangement of the ductus choledochus and the major pancreatic duct.

ANATOMIC CONSIDERATIONS

A study of the embryology clearly indicates that there must appear in a considerable number of cases a high union between the common and pancreatic ducts, since in those cases in which the ventral pancreatic bud comes off the hepatic diverticulum, it is carried away from the gastrointestinal stem as the common duct lengthens. Many anatomic

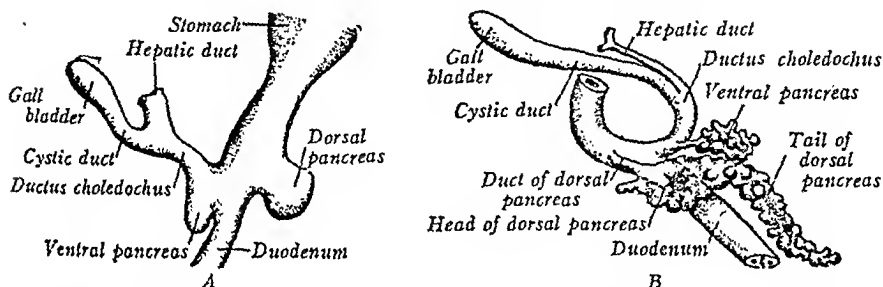


Fig. 1.—Reconstruction of the pancreatic primordia and main hepatic ducts in human embryo. (From L. B. Arey, *Developmental Anatomy*, Philadelphia, 1934, W. B. Saunders Company.)

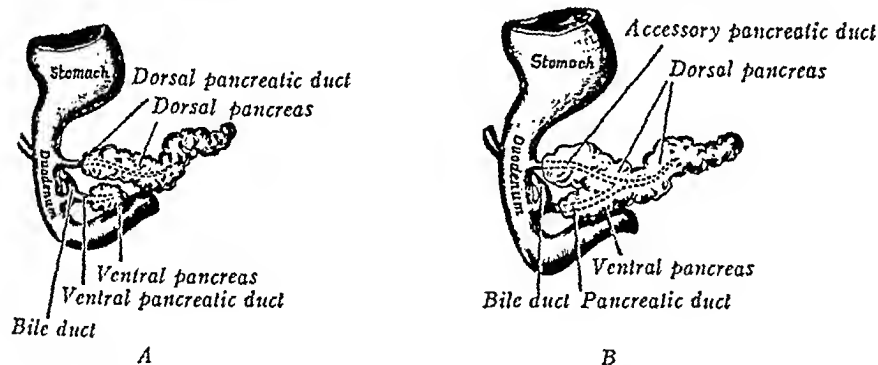


Fig. 2.—Origin and fusion of the two pancreatic primordia. (From L. B. Arey, *Developmental Anatomy*, Philadelphia, 1934, W. B. Saunders Company.)

studies have been made in an effort to determine the variations in the adult of the relationship between the common and pancreatic ducts at their junction near their exit into the duodenum, especially as to whether a common passageway could be demonstrated. All investigators have pointed out that, in the event of a common ampulla which is obstructed by a calculus, a continuous pathway between the pancreatic and biliary passages can exist only if the common ampulla has a length greater than the diameter of the duodenal orifice. In some carefully conducted studies on 100 necropsy specimens, Cameron and Noble demonstrated that in 65 per cent it was anatomically possible for a biliary

calculus lodged in the ampulla of Vater to cause a reflux of bile up the duct of Wirsung, or to cause a continuous pathway between the biliary and pancreatic systems. Westphal and Ruge stated that the percentages were 84 per cent and 75 per cent respectively, whereas Mann and Giordano found that in only 3.5 per cent is it anatomically possible for an obstruction at the duodenal end of the ampulla to convert the ducts into a continuous pathway. From these anatomic studies it must be concluded that in a large percentage of cases, in the event of an obstruction at the duodenal orifice by a calculus, a freely communicating passageway is formed between the biliary and pancreatic systems in which bile may enter the pancreatic ducts and pancreatic juice into the biliary system.

Other factors than calculi may play a rôle in the process of partial or intermittent duct occlusion at the papilla, thus forming a continuous pathway. Archibald believed that a spasm of the sphincter of Oddi might lead to increased pressure within the ducts, thus forcing bile into the pancreatic duct, causing pancreatic necrosis. This is controverted by Moynihan, and Mann and Giordano. Del Valle called attention to pathologic changes at the outlet of the ampulla, the result of stone, with infection, which he classified as: 1, hypertrophic papillitis; 2, atrophic papillitis; 3, erosive papillitis; 4, cholesterinic papillitis; 5, vegetative papillitis; and 6, phagedenic papillitis. Del Valle believed that these lesions accounted for the painful and distressing syndromes which occurred, at times, after gallstone operations and that the mechanism involved was spastic irritability of the sphincter with, in some instances, cicatrization and obstruction at the duodenal orifice.

If the hypothesis of a common pathway between the biliary and pancreatic systems is accepted, it becomes obvious that an interchange of pancreatic juice and bile in the ducts is possible. Nordmann ligated the ampulla and subsequently found bile in the dilated pancreatic ducts of the experimental animal. Delmore reported an instance in which, during an appendectomy, the gallbladder was squeezed in order to determine whether it would empty. Within twenty-four hours an acute pancreatitis developed. These observations would lend credence to the theory that it is possible for bile to enter the pancreatic system. Harms and Dragstadt have shown that during the height of digestion the pancreatic secretory pressure is greater than the biliary, therefore a reflux of pancreatic juice into the biliary ducts might be anticipated. We have shown that India ink introduced into the terminal end of the common duct of the dog will, at times, enter the gallbladder; hence, if pancreatic juice finds its way into the common duct, it, too, may ascend and enter the gallbladder.

If the assumption is correct that there may be an interchange of bile and pancreatic juice in the common duct and that pancreatic juice

may enter the gallbladder, it then remains to be proved what effect the pancreatic juice will have upon the ducts, liver, or gallbladder.

The entity, "acute nonperforative biliary peritonitis," was first described in 1910 by Clairmont and Haberer, their theory being that bile filtered through the wall of the gallbladder in the presence of duct occlusion. In 1918, Blad proved, however, by animal experiments, that the instillation of pancreatic juice into the gallbladder produced a biliary peritonitis in which the macroscopic appearance of the gallbladder was normal while microscopically extensive necrosis existed. We have corroborated this finding. The admixture of the bile with pancreatic juice leads to a "digestion necrosis" of the walls of the gallbladder, the bile passing through the wall of the gallbladder into the free peritoneal cavity. In 1923, Seifert observed a clinical case in which diastase was found in the bile, and in 1924, Schönbauer reported a case of gangrenous cholecystitis with a biliary exudate in the peritoneal cavity, trypsin being present in the bile. Bundschuh, in 1927, reported a case with a stone impacted in the ampulla and with a nonperforative biliary peritonitis in which pancreatic enzymes were isolated from the peritoneal fluid. In 1928, Ruppner also reported a case of a stone impacted in the ampulla with biliary peritonitis in which pancreatic enzymes were found in the bile. In 1930, Popper reported a very interesting case:

CASE REPORT.—A male, aged fifty-one years, was operated upon because of acute abdominal symptoms referable to the right side of the abdomen, a tentative diagnosis of acute appendicitis or acute cholecystitis having been made. Upon opening the abdomen, a large amount of a bile-stained fluid was found with fat necrosis of the omentum in the vicinity of the gallbladder. The gallbladder was found to be distended, large, and very tense, and the wall appeared to be edematous. The common duct was enlarged to the size of a thumb. There was no evidence of a perforation of the gallbladder; the stomach and duodenum appeared normal; and there was no evidence of tumor growth or obstruction. The pancreas was somewhat enlarged and firmer than normal, but no striking gross changes were noted. The gallbladder bile was turbid and dark green; no stones were found in the gallbladder or common duct, a large sound passing readily through the papilla. A cholecystectomy and drainage of the common duct were performed, and the patient recovered. The peritoneal exudate contained diastase values of $\text{df } \frac{38}{30} = 1024$, and the gallbladder bile, $\text{df } \frac{38}{30} = 4096$; trypsin could not be detected in the peritoneal exudate, which contained albumin; however, the gallbladder bile contained 9 units by the Fuld and Gross technic. At the time of operation, the blood diastase values were $\text{df } \frac{38}{30} = 32$. The peritoneal exudate and the gallbladder contents were sterile, and the gallbladder, aside from being red, revealed neither gross nor microscopic changes. Numerous examinations were made of the biliary drainage in the days following the operation, but no evidence of pancreatic enzymes could be found; however, on the twelfth postoperative day, the drainage material was darker in color and cloudy.

Examination revealed diastase values of $\text{df } \frac{38}{30} = 4096$ and trypsin 8 units. These findings lasted only a few hours, and pancreatic enzymes were never again found in the biliary drainage.

Popper reasons that a small calculus became impacted in the papilla allowing pancreatic juice to find its way into the gallbladder, thus causing the pathologic picture; the calculus was forced through the papilla before the operation was performed, but an undiscovered stone remained in the dilated duet which later obstructed the papilla for a short period of time and was then expelled into the duodenum. Popper explains the process of acute nonperforative biliary peritonitis on the basis of obstruction of the biliary passage at the ampulla by stone; dilatation of the duets follows, and there is a mixture of bile and pancreatic juices in the dilated duets. Due to the excess of pressure in the pancreatic system, bile mixed with pancreatic juice enters the gallbladder and is rendered diffusible so that it passes through the wall of the dilated gallbladder. Bernhard, Dziembowski, and Brackertz have reported cases of nonperforative biliary peritonitis, and in 1934, Melehoir reported three cases. Bernhard stated, in 1931, that seventy cases had been observed and reported since the condition was first mentioned by Clairmont and Haberer. Birgfeld, in 1931, reported a typical case which followed a gastric resection for ulcer.

It must be conceded that whatever may be the mechanism of production of acute nonperforative biliary peritonitis, pancreatic enzymes have been found in the gallbladder contents and in the peritoneal fluid in these cases; also, that in some instances, notably those of Blad, Bundschuh, and Ruppaner, extensive necrosis of the gallbladder wall was present. Popper has, in my opinion, proved that the diastase is not carried to the gallbladder or peritoneum by way of the blood stream, but that it enters the gallbladder by a direct route, via the biliary and pancreatic passages. Since pancreatic enzymes are found in the gallbladder contents and peritoneal fluid, in cases of acute nonperforative biliary peritonitis, the question remains whether it may be the inciting factor in the production of changes in the wall of the gallbladder noted in some of these cases, and whether it may also produce other and less extensive pathologic changes noted in cases of acute, subacute, and chronic cholecystitis.

In 1931, I reported a series of experiments in which it was demonstrated that when pancreatic juice was introduced into the gallbladder, degenerative changes occurred in the wall of the gallbladder.

These experiments consisted of: (1) a single injection of pancreatic juice into the gallbladder through a hypodermic needle; (2) multiple injections of pancreatic juice into the gallbladder through a cholecystostomy tube; (3) a single injection of pancreatic juice into the cystic duet through a hypodermic needle; (4) a single injection of pancreatic

juice into the common duct through a hypodermic needle; and (5) the continuous introduction of pancreatic juice into the common duct by means of a special preparation (choleodochopancreatic intubation).

In every instance the gallbladder wall showed evidence of pathology; a normal gallbladder was never found in which the procedure or preparation used was considered successful. In every instance in which cultures were made, they were positive; the predominating organisms found were staphylococci and the colon group. The pathologic changes were characterized as degenerative and regenerative. In the accepted experiments, seventeen animals showed complete necrosis of the gallbladder, while eight showed incomplete necrosis with some evidence of reparative effort. In nineteen animals, the changes were classed as regenerative; these included hypertrophic, hyperplastic, and inflammatory reactions. The details of these experiments were published in 1931. It was noted "that the changes in the wall of the gallbladder have a degree of similarity, whether the pancreatic juice was introduced directly into the gallbladder through a needle, injected into the cystic duct or common duct with a needle, or continuously introduced into the common duct by means of a special preparation, choleodochopancreatic intubation. It would seem that the sudden introduction of a relatively large amount of pancreatic juice, 20 c.c., is more likely to produce extensive changes than when smaller amounts are injected or when a choleodochopancreatic intubation is used."

The conclusions drawn at that time were as follows: "A study of the microscopic changes in the various gallbladders would lead one to believe that under some conditions, the pancreatic juice brought about a prompt destructive action on the wall of the gallbladder as represented by a noninflammatory necrosis with edema. At other times, only partial necrosis took place with ulceration of the mucosa with, at times, rather marked changes in the muscular wall and thickening of the serosa. The changes in the muscular and serous coats appeared to be a reactionary response of the tissues to the destructive agent; inflammatory cells were called forth; edema was present; and in every way the process looked like typical inflammatory reaction."

In some instances, the process was typically a reactionary or inflammatory response as evidence that necrosis was either absent or present in a minor degree. There were all degrees of reaction from acute inflammatory manifestations with leucocytic infiltration and edema to the typical chronic changes characterized by lymphoid and papillary hyperplasia and cyst formation. The question arose as to whether the necrosis may not have been a postmortem process, either an autolysis or a postmortem digestion of the gallbladder wall by the pancreatic juice which had been introduced during the time of the experiment, and that the pancreatic juice did not attack the living tissues. We are convinced that in those

animals in which the autopsy was performed immediately after death and in those which were killed and the autopsy immediately performed, the necrosis was antemortem and associated with the introduction of pancreatic juice.

These experimental observations bear a close relationship with those of Blad, Schönbauer, Westphal, and Brackertz. Westphal used human duodenal juice which had been assayed as to trypsin and amylase content and passed through a Berkefeld filter to insure sterility. He introduced the duodenal juice into the gallbladder by a transduodenal cannulization of the common duct using a small catheter, thus obviating the possibility of trauma to either the ducts or gallbladder. He noted in two dogs, four or five minutes after the introduction of the duodenal juice, that the gallbladder showed evidence of gross changes. In one dog which died ten hours after the introduction of 8 c.c. of duodenal juice, the gallbladder was completely necrotic.

Andrews, Goff, and Hrdina have shown that when pancreatic juice was introduced into the gallbladder of the dog, pathologic changes occurred in every instance; however, when the pancreatic juice was passed through a Berkefeld filter, the changes were very much less. Brackertz concluded from his experiments that pancreatic extract mixed with colon bacilli when introduced into the common duct in the presence of stasis leads to necrosis of the wall of the gallbladder within twelve hours, but that pancreatic juice alone with stasis or pancreatic juice mixed with colon bacilli without stasis causes no changes in the wall of the gallbladder. These conclusions suggest that a bacterial contamination may be a deciding factor in the mechanism. Again we may turn our attention to work done on the relationship of the bile as a factor in the production of acute pancreatic necrosis. The observations of Nordmann have already been alluded to. With simple ligation at the ampulla, the pancreatic ducts were dilated; the contents consisted of bile-stained fluid, but there existed no necrosis of the pancreas. With the introduction of cultures of dog's feces into the gallbladder, prompt necrosis of the pancreas occurred. Binet and Brocq introduced sterile pus from an old empyema into the duct of Wirsung of an experimental animal, and acute necrosis of the pancreas resulted. Lombardi, in discussing the subject of pancreatic juice activation as a factor in the production of acute pancreatic necrosis, states that the enzymes are known to be activated by certain substances, such as enterokinase, a secretion of the upper intestinal tract. He also believes that there is a cytokinase, such as may be liberated by leucocytes and perhaps other cells, and a bacteriokynase. Relative to the latter, it is difficult to determine whether this activating substance is a product of bacterial lysis or a toxin which may be elaborated by the living bacteria. The conclusions of Lombardi are sustained by clinical experience, for it is known that

operations can be performed upon the pancreas without subsequent necrosis if three precepts are observed: sharp dissection, complete hemostasis, and no infection.

It would appear that bacteria play a rôle in the experimental production of pathologic changes in the gallbladder with the use of pancreatic juice. It is a known fact that gallbladder disease cannot be produced by the introduction of bacteria into the gallbladder, but it has been conclusively proved that pancreatic juice, with bacteria, leads to varying degrees of changes in the wall of the gallbladder. Unactivated, sterile pancreatic juice is practically inert, for Dragstadt has shown that 100 c.c. of pancreatic juice which has been passed through a Berkefeld filter can be introduced into the peritoneal cavity of a dog and cause no disturbance or fat necrosis, but 50 c.c., or less, when not passed through a Berkefeld filter, will produce death. On the other hand, bacteria are commonly present in the biliary and pancreatic secretions. It is known that, in the dog, in 70 per cent of cases, the mucosa of the gallbladder contains bacteria, and in 30 per cent, the bile contains colon bacilli and staphylococci; moreover, Dragstadt reports that in 90 per cent of experimental animals, the pancreas yields positive cultures. Considering the fact that the dietary habits of the human are not those of the dog, nevertheless, it is reasonable to conclude that frequently in the human being the bile and pancreatic secretion will contain bacteria.

The preponderance of the experimental evidence indicates that stasis is an important factor in the production of gallbladder disturbance when pancreatic juice is mixed with the bile. In the human being, stasis is relatively common. It may be a purely functional affair or produced by disease of the papilla or due to intermittent occlusion at the papilla by stone. I am of the opinion that low grade stasis, such as may be produced by spasm or partial stenosis at the papilla, is more likely to produce a pancreatic juice reflux into the gallbladder than stone impaction in the ampulla. The probability of an impaction of a small stone in the papilla, thus creating a continuous pathway, requires a high union of the two ducts so that the stone will not interfere with the passageway between the biliary and pancreatic ducts. This may be relatively uncommon. Birgfeld cites a case in which, after a gastric resection, the patient developed an acute biliary peritonitis. At operation the duodenal stump was found to be well closed, but the gallbladder was markedly distended and dark greenish brown in color. He attributed the change in the gallbladder to a reflux of duodenal contents into the biliary passages, since later he demonstrated in this individual by roentgen study that the barium entered the duodenum and distended it. A man upon whom I had performed a posterior gastroenterostomy for a pyloric carcinoma died approximately twelve days after the operation. The autopsy disclosed a gangrenous cholecystitis. It is entirely

possible that in these cases a reflux of pancreatic juice may have been the etiologic factor in the production of the gallbladder pathology.

HYPOTHESIS

Embryologic and anatomic evidence indicates that it is possible, in the human, for a continuous pathway to exist between the pancreatic and biliary systems in a considerable percentage of cases. Since the secretory pressure of the pancreas is greater than that of the biliary system, in the presence of obstruction at the papilla, it is possible for pancreatic secretions to mix with bile in the common duct. The obstruction may be complete, such as that produced by a stone impacted in the ampulla; or it may be incomplete or intermittent. Ivy has shown that biliary stasis is common without definite organic obstruction of the duct at its entrance into the duodenum. There are many clinical examples proving the fact that the pancreatic juice may enter the gallbladder and that, associated with this phenomenon, there may exist necrosis of the gallbladder with or without a biliary peritonitis. A number of observers have called attention to cases of acute gangrenous cholecystitis in which cultures from the gallbladder walls or contents were sterile, the process suggesting an acute digestion of the gallbladder wall. Recently Colp, Gerber, and Donbilet reported three cases of acute cholecystitis, the gallbladder bile in two containing both amylase and trypsin and in one containing only amylase. In two cases, cultures were negative, the other revealing both *Bacillus Friedländer* and *Bacillus coli*. In two cases, free bile was present in the peritoneal cavity, and in one case, fat necrosis was present throughout the gallbladder wall and in the omentum adherent to the gallbladder. Experimental evidence clearly indicates that the pancreatic juice may affect the walls of the gallbladder under variable conditions and produce different types of changes, varying from acute necrosis to chronic hyperplastic and inflammatory reactions. Assuming these observations to be true, the following hypothesis may be constructed:

Under normal conditions the bile passes through the ducts to be emptied into the duodenum, some entering the gallbladder to be concentrated and later to be expelled into the common duct. The pancreatic juice may enter the duodenum by a direct passage or may fuse with the bile in the ampulla. Brackertz has shown experimentally that even in the presence of extensive changes in the gallbladder wall, due to the presence of pancreatic juice the bile ducts are not involved. He believes this is due to the fact that there is much more elastic tissue underlying the mucosa of the ducts than is in the wall of the gallbladder. The elastic tissue is very resistant to the action of pancreatic juice. In experiments in which he introduced pancreatic extract mixed with colon bacilli into the common duct and obstructed

the duct, marked changes took place in the wall of the gallbladder, but the ducts remained normal except for, at times, localized necrotic changes in the wall of the duct at the site of the duct puncture. It is therefore logical to assume that without stasis and with normal anatomic and physiologic mechanisms even though the duct bile may be mixed with pancreatic juice no pathologic changes take place in the biliary passages.

With low grade stasis in the biliary passages such as may be produced by disturbed papillary function or by complete or incomplete obstruction at the duodenal end of the biliary and pancreatic ducts, the bile mixed with pancreatic juice may remain in the ducts for a considerable time, the bile-pancreatic juice ratio being altered, and variable amounts of pancreatic juice enter the gallbladder. The disturbance created in the gallbladder will then depend upon known and unknown factors. If the pancreatic juice content is low and no bacterial contamination is present, no changes may occur in the wall of the gallbladder. If, however, the pancreatic juice content is higher, the stasis prolonged, and possibly a low grade bacterial contamination is present, changes may occur as described by Andrews, Goff, and Hrdina. They have shown with the introduction of pancreatic juice into the gallbladder of the dog that the cholesterol content of the bile is not altered, but that the concentration of the bile salts is reduced to less than one third. In five experiments, with unfiltered pancreatic juice, all the bile salts had been absorbed leaving the cholesterol precipitated. Therefore, in the human being, the low dilution stage may be a factor in the production of gallstones. When the concentration of pancreatic enzymes in the gallbladder bile is high, the pathologic changes produced will depend upon complete or incomplete activation of the pancreatic enzymes in greater or lesser dilution in contact for short or long periods of time, sufficient time and concentration being necessary for necrosis.

It is not the purpose of this paper to convey the idea that all cases of cholecystitis or gallstones are produced by a reflux of pancreatic juice into the gallbladder; however, I am convinced that the cause of selected cases of acute necrosis and acute gangrenous cholecystitis and also cases of chronic cholecystitis with or without stone can be found in a reflux of pancreatic juice into the gallbladder.

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THE EQUAL DIVISION AND DISTRIBUTION OF THE DIET AND INSULIN IN TREATING THE DIABETIC WITH SURGICAL COMPLICATIONS AND ACUTE INFECTIONS*

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A NEED exists for an outline of a simple, practical, and effective treatment for diabetic patients having acute infections and surgical complications.

Much has been written on the various types of diet for these patients, but little has been said of its distribution, or of that of the insulin. This results in confusion to all but specialists in the treatment of diabetes. Clarke and others¹ reported benefits from equal division of the insulin with frequent administrations, but apparently the diet was not so altered.

The prescribing of the total diet may be dispensed with by noting that the average adult for each twenty-four hours requires a minimum of $\frac{2}{3}$ gm. protein per kilogram of body weight, and more in prolonged fevers. The carbohydrate allowance is at least 150 gm. and preferably 200 or higher in the overweight patient. The fat quota is low but is sufficient to keep the total calories at 25 per kilogram of body weight or higher in prolonged fevers.

It is sufficient to say that all diabetics with acute infections, fever, or those requiring surgery should receive unmodified insulin temporarily at least.

DIET AND INSULIN DISTRIBUTION

In dealing with acute infections and postoperative and postketotic diabetic patients and recently during confinement of our pregnancy cases, we have adopted the practice of dividing the diet—liquid, soft, or combined as indicated—into four, five, or six equal feedings according to the intensity of the fever, the magnitude of the operation, the severity of the diabetes and the necessity of having these feedings equally spaced in the twenty-four hours. Similarly the insulin is equally divided so that each dose precedes or, in the case of digestive upsets, may follow each feeding. This regime has been illustrated in a previous publication.²

Following operations, for six to twenty-four hours, when oral feeding may be impractical, or at other times when the patient is unable to take food by mouth, the carbohydrate equivalent of a feeding may be given

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intravenously in the form of glucose, 5 or 10 per cent solution, at the scheduled feeding times. In this event, two-thirds of the planned dose of insulin is given.

In presenting the basis for this treatment, a word about the effects which changes in the total metabolism have on diabetes is appropriate, because these changes indicate the alteration of the program from that for the noncomplicated to that for the complicated diabetic. Allen, and his associates,³ proved that a reduction in body weight, as a result of undernutrition, improved the diabetic's food tolerance and that an increase in the body weight had the opposite effect. It is well known that if a diabetic, standardized on a diet and insulin regime, gains in weight, the insulin need is increased. This is especially noticeable in children. Hyperthyroidism,⁴⁻⁶ adrenal⁷ and certain pituitary tumors also aggravate the diabetes and in consequence increase the insulin requirement. In the event of pregnancy,⁸ infection,⁹ fever, and toxemia (see illustrative cases below), desiccated thyroid,^{2, 10} epinephrine, dinitrophenol or prolonged roentgen ray therapy, increased calorie intake, and some cases of acute myocardial insufficiency, the same result ensues. In other words, *any factor, physical exercise excepted, which increases the total metabolism, increases the insulin need.* The previous dosage becomes inadequate. The reverse is also true. Removal of the thyroid gland in man, as shown by Wilder,¹¹ and Rudy,¹² or the anterior pituitary or adrenals as proved experimentally by Houssay and Biasotti,¹³ Long and Lukens,¹⁴ and others, lessens the severity but does not cure the diabetes; so also does a reduction in weight (Benedict¹⁵ found that a loss of 10 per cent of the body weight decreased the total metabolism 19 per cent), a reduction in the calorie intake, eradication of infection or toxemia, stopping desiccated thyroid,^{5, 10, 16} epinephrine or dinitrophenol therapy, giving iodides to diabetics with Graves' disease,^{14, 18} the spontaneous development of myxedema,¹¹ and approaching old age.* Though altering body physiology in divergent ways, these conditions in common *reduce the total metabolism and simultaneously alleviate the diabetes.* Exception is made to the cessation of physical exercise, which, while decreasing the total metabolism, does not alleviate the diabetes, but has rather the opposite effect. A relative and absolute increase in combustion of carbohydrate coincident with physical work done may account for the decrease in the blood sugar which accompanies the increased total metabolism associated with physical exercise and vice versa.

The total metabolism must not be confused with the basal metabolism. The total metabolism is elevated if the basal rate is above normal, but the basal metabolism may be normal with an abnormally high total metabolism. For instance, the basal rate may be normal for the surface

*The decrease in the total metabolism in old age accounts, we believe, for the remarkably few new cases of diabetes in people over sixty-five years of age.

area of a patient weighing 120 kg. but whose normal weight is 80 kg. It is obvious, however, that the total metabolism is above that of the normal person of the same age, height, and sex.

Clinically, increases in the total metabolism, that due to physical exercise excepted, shorten the period of insulin effectiveness. The dose of insulin which previously maintained a satisfactory blood sugar concentration no longer does so, hence the need for larger doses or an approximation, and an increased number of doses is created.

The uncomplicated diabetic exercises in the daytime. It is physiologic that the diet and insulin should be given at this time when the metabolic activity is greatest.

The diabetic with infection or fever confined in bed—thus deprived of the influence which exercise has on the oxidation of sugar—has an increased total metabolism throughout the twenty-four hours, hence *the need for food and insulin is equally as great at night as in the daytime.* These needs are best supplied with least difficulty and, to our belief, with best results by frequent and equal spacing of insulin and meals. Illustrative cases as well as a summary of eighty cases are presented. By virtue of this equal division and spacing of the diet, the insulin can be divided into equal doses. The insulin, based on the results of fractional urinalyses, a specimen before each feeding being examined, is increased to overcome glycosuria and hyperglycemia, or decreased when the need arises to prevent insulin reactions.

Six feedings and six doses of insulin are used in the presence of severe infections, high fever, and immediately after surgical operations (four hourly feedings). The less severe infections with moderate fever or a moderating severe infection would indicate a division into five meals and five doses of insulin given at five-hour intervals, and a mild fever or a mild infection, four meals and four doses of insulin given at six-hour intervals. Three meals and three doses are resumed when convalescence is established.

ILLUSTRATIVE CASES

CASE 1.—F. H., female, aged sixty-seven years, was admitted to the Pennsylvania Hospital on March 2, 1934, for the treatment of diabetes and gangrene. She complained of severe pains in her legs. Her family history was unimportant, and her only past illness was pneumonia in childhood.

Present illness: In 1931, after a minor injury to her right great toe, a vesicle appeared at the site of injury. The entire toe became inflamed. Glycosuria was found, and a diagnosis of diabetes with gangrene was made. A special diet and insulin were given, and the patient was confined to bed for five weeks with good results.

Five days prior to admission, another vesicle appeared on the fifth toe of the left foot. The underlying tissues became black. At this time, an ulcer appeared on the distal third of the right leg.

The positive findings on physical examination were: undernutrition, marked thickening of the peripheral arteries, arterial hypertension, retraction of the left

nipple with an irregular mass, which proved to be a benign tumor in the left upper quadrant of the breast, emphysema with fine crackling râles at the base of each lung, and mitral insufficiency with enlargement of the heart. There was a feeble pulsation in both dorsalis pedis arteries, and the feet were cool to touch. The affected toe was gangrenous, emitting a foul odor and a purulent discharge.

The patient was considered a poor surgical risk. Watchful waiting was advised by the surgeons.

Insulin was begun again on May 4 and was steadily increased. In May and June, the gangrene extended, involving the plantar surface of the foot with profuse purulent discharge. There was continued fever. Radical amputation was decided upon.

Control of the diabetes was maintained by adding to the insulin, which was given in five doses, and with a diet of 70 gm. of protein, 36 gm. of fat, and 200 gm. of carbohydrate (1,400 calories) (see Table I). The diet was given in five equal feedings evenly distributed throughout the twenty-four hours (five hourly intervals).

On the day of operation, June 6, the usual amounts of insulin were given before liquid meals at 7:00 A.M. and 10:00 A.M. At 11:45 A.M. a spinal anesthetic (neocaine) was administered, and at midday 10 units of insulin were given. The left leg was then amputated at the midhigh level by Dr. A. Walking. Following the operation 250 c.c. of a 10 per cent solution of glucose was given intravenously. This was repeated at 4:00 P.M. with 20 units of insulin. Ginger ale and orange juice were given freely.

The liquid meals, 6, equally spaced, in twenty-four hours, were resumed at 8:00 P.M., each being preceded by 22 units of insulin. House diet of appropriate values was allowed on June 8. A rapid decrease in the insulin need ensued. On June 13, the feedings and insulin doses were reduced to 5 in number, and on June 15, to 4. Uneventful recovery ensued.

CASE 2.—H. M., male, insurance salesman, aged 29 years, weight 66 kg. (146 pounds), entered the Pennsylvania Hospital January 1, 1936, complaining of pain in back, made worse by deep breathing, fever, and general weakness.

Family History: Irrelevant. **Past Illnesses:** Influenza in 1918, furuncle in groin in 1920, and the diabetes recognized in 1932. This was controlled by a weighed diet with insulin 3 times daily. The dosage at the onset of the present illness was 20 units before breakfast, 12 before lunch, and 14 in the evening.

Present Illness: On December 15, he contracted an acute upper respiratory tract infection. He continued at work with no improvement and was seen by one of us (G. G. D.) on December 27. He had a nasal discharge and a productive cough but no fever. On January 1, he was awakened by a sharp, stabbing pain in the left side of his back. A productive mucopurulent and increasingly blood-streaked sputum followed, and he had a severe chill. He became nauseated, and because of this omitted his noon insulin. The evening nourishment and insulin were taken. He was then seen by Dr. C. Nissler who, finding early signs of lobar pneumonia, advised his admission.

Physical Examination: Appeared acutely and seriously ill, temperature, 104° F.; pulse, 104; respirations, 28; blood pressure, 120/60; moderate cyanosis of mucous membranes; face flushed, tongue coated, dental caries, nasal discharge, injection of nasopharynx, limited expansion with dullness to percussion, and moderate suppression of breath sounds over the right lower lobe. The liver edge was palpable.

Progress Notes: On January 2, the signs of consolidation were pronounced. The patient continued very ill, and on January 6, signs of fluid at the right base were observed, and 500 c.c. of serosanguineous fluid were removed. On January 7, he was quite jaundiced, and signs of consolidation of the entire right upper lobe

TABLE I*
DIET, INSULIN TREATMENT, AND LABORATORY DATA OF A DIABETIC PATIENT WITH
GANGRENE NECESSITATING AMPUTATION. CASE 1.

DATE 1934	TIME	DIET				INSULIN				BLOOD SUGAR	GLYCOSURIA	
		P	F	G	CAL.	26	24	25	25			
June 4		70	36	200	1400	26	24	25	25	98	0 0 0 0	Liquid diet
5	7:00	70	36	200	1400	26	24	25	25		0 0 0 0	
6	10:00	12	7	33	243	26						
	11:57	12	7	33	243	24						Leg amputated Glucose by vein
	12:20					10						
	12:35											
	4:00			25	100							Negative
	8:00			60	240	20				67		
	12:00	12	7	33	243	22						
7		12	7	33	243	15				130		Negative
	4:00	12	7	33	243	15						
	8:00	12	7	33	243	15						
	12:00	12	7	33	243	15						Negative
	4:00	12	7	33	243	15						
	8:00	12	7	33	243	15						
	12:00	12	7	33	243	15						House diet (6 meals)
8		70	36	200	1400	12	12	12	12	122	0 0 0 0	
9		70	36	200	1400	9	9	9	9	121	0 0 0 0	
10		70	36	200	1400	7	7	7	7	133	0 0 1 0	
11		70	36	200	1400	6	6	6	6		0 0 0 0	5 meals
12		70	36	200	1400	6	6	6	6	126	0 0 0 0	
13		70	36	200	1400	6	6	6	6	181	0 0 0 0	
14		70	36	200	1400	6	6	6	6	133	0 0 0 0	4 meals
15		70	36	200	1400	9	9	9	9	152	0 0 0 0	

*Illustrates the equal division of the diet into 6, then 5, and lastly 4 feedings as convalescence was established. The insulin was similarly divided and likewise equally spaced in time of administration.

TABLE II*
DIABETES COMPLICATED BY LOBAR PNEUMONIA, CASE 2

DATE	DIET				INSULIN DISTRIBUTION	TOTAL UNITS	BLOOD SUGAR		URINE SUGAR		
	P	F	C	CAL.			A.M.	P.M.	QUAL.	QUANT. GM.	
12/27-31	100	126	115	2000	27-13-19	59					Prior to admission
1/1	60	40	250	1600	27-0-19-10-10-10	76					Admitted
2	60	40	250	1600	10-10-10-10-10-10	60	280		4+	5.7	6 feedings
3	60	40	250	1600	10-10-10-10-10-15	65	283		4+		
4	60	40	250	1600	15-15-20-20-20-10	120	293	326	4+ to 2+	23.1	
5	60	40	250	1600	50-10-40-10-50-10-60-20-50-50	370	307	150	4+ to 0	34.7	
6	60	40	250	1600	10-30-30-10-30-10-30-10-35-10-35	240	223		1+ to 4+	18.0	
7	60	40	250	1600	10-35-10-35-10-35-10-35-10-35	270	205		1+ to 2+		
8	60	40	250	1600	10-35-10-35-10-35-10-35-10-35	270	180		2+ to 0		
9	60	40	250	1600	35-35-35-35-35-35	240	66		0		
10	60	40	250	1600	30-30-30-30-30-30	205	123		0 to 1+		
11	60	40	250	1600	25-25-25-25	150	55		0 to 1+		
12	60	40	250	1600	20-20-20-20	100	185		0		5 feedings
13	60	40	250	1600	20-20-20-20	80			1+ to 3+		4 feedings
14	60	40	250	1600	20-20-25-25	90	249		0 to 1+		
16	60	40	250	1600	25-25-25-25	100	98		0 to 1+		
19	60	40	250	1600	20-20-20-20	80	93		0 to 2+		
20	60	40	250	1600	20-12-19-8 (9 P.M.)	59			1+		3 feedings with late nourishment
2/1/32	60	40	250	1600	23-12-17-6	58	91		0		†Protamine insulinate
4	60	40	250	1600	23-12-23†	58			0 to 1+		
9	60	40	250	1600	23-12-23†	58	150				

Heavy figures represent dose prior to nourishment, italics those between feedings—see text.
*Depicts the diet and insulin and their distribution, and laboratory data.

TABLE III
DISORDERS COMPLICATING DIABETES WITH ILLUSTRATIVE DIET AND INSULIN REGIMES EMPLOYED

	NO. OF CASES	DIET				INSULIN		DEATHS
		P	F	C	CAL.	FEED-INGS	HIGH-EST TOTAL	
Acute abdominal conditions: abdominal teratoma (1), appendectomy (4), cholecystitis and cholecystectomy (4), hysterectomy (2), pancreatitis (subacute) (1), salpingectomy (bilateral), right oophorectomy, removal of cyst from broad ligament (1), suspension of uterus and perineal repair (1)	14	60	17	225	1300	6	130	0
Amputations								
Carcinoma (penis, cervix, thyroid, and esophagus). (Two recovered from the operation but died later of metastases.)	9	70	35	200	1400	6	123	2
Conn-inspending or after coma only.	4	60	51	225	1600	6	116	1
Cutaneous and subcutaneous infections: abscesses (5), carbuncles (?) (one case had complicating grave cardiac decompensation), cellulitis and erysipelas (1), furunculosis, large abscess of scalp and pneumonia (1) (died on third day after admission)	8	80	42	200	1500	6	120	0
Gangrene with secondary infection, but without amputation	16	65	60	200	1600	6	240	1
Gonorrheal epididymitis	3	65	42	190	1400	5	85	0
Mastoidectomy operation	1	70	82	120	1500	4	80	0
Osteomyelitis (one patient died 6 months after operation of pulmonary tuberculosis)	2	65	37	200	1400	6	72	0
Pneumonia (lobar)	4	60	73	150	1500	4	82	0
Postpneumonic empyema (thoracotomy)	11	60	62	225	1700	6	98	1
Postpneumonic lung abscess (patient whose regime is illustrated had Friedländer's pneumonia with bilateral pulmonary abscess, 1 drained by posture, and 1 by operation. Recovery)	2	75	65	200	1700	5	75	0
Pneumonia (broncho-) (one patient was in precoma, and had an acute pyelitis; the other had a complicating gangrenous foot; both elderly)	2	50	55	200	1495	6	175	0
Trauma from auto accident and fractured tibia	3	60	62	200	1600	5	125	2
Total	1	75	120	200	2180	5	60	0
	80							7

with beginning resolution at the base were noted. One hundred cubic centimeters of serous fluid were removed. Clinical improvement with a fall in temperature by lysis, leading to recovery, began on January 8.

Laboratory Studies: Studies pertaining to the diabetes are presented in Table II. The urinalysis (on admission) was normal except for the presence of clumps of white blood cells. Blood Count: January 2, hgb. 77 per cent; R.B.C., 3,920,000; W.B.C., 10,350. January 3, 15,300; January 12, 16,600. The blood Wassermann reaction and the Kahn precipitation tests were negative.

Sputum: Culture and routine typing, pneumonia Type I—pathogenic to mice. **Pleural fluid:** Smear revealed many polymorphonuclear cells, few lymphocytes, frequent large mononuclears and some large multinucleated cells and no organisms. There was no growth on culture. Blood culture—no growth (twelve days). Roentgen ray studies by Dr. Paul Bishop confirmed the physical findings.

Comments.—The diet was 60 gm. protein, 250 gm. carbohydrate, and sufficient fat to make 1,600 calories and was given in liquid form and divided into 6 equal feedings, equally spaced in the twenty-four hours. *Insulin*, 10 units were given before each of the 6 feedings, but this proved inadequate and the dosage was rapidly increased to 50 units before each nourishment. This dosage proved insufficient. The effect of each dose of insulin was exhausted before the next one was due. Accordingly at the midpoint between feedings, an additional 10 units were given. This is the only patient, in our experience, in whom this additional measure has been found necessary. The unusually severe demand resulted in a total dosage of 370 units on January 5.

The midpoint doses (between meals) were discontinued on January 10, and the doses before nourishments were gradually decreased (see chart). The diet was divided into 5 feedings on January 11, and on January 12 into 4 feedings with 25 units of insulin before each. Later, 20-unit doses were sufficient. On January 20, the diet was divided into 3 meals with a bedtime nourishment saved from supper with 4 doses of insulin, 20 units before breakfast, 12 at noon, 19 before supper, and 8 at 9 P.M.

By using protamine insulinate (Lilly), the two evening doses were combined and given before supper. Details of this aspect of the study will be given elsewhere.

Table III depicts: (1) the results in treating diabetics having acute infections and surgical complications; (2) an illustrative diet and its distribution for each group; and (3) an illustrative insulin dosage and its distribution. Less severe disorders (tonsillitis, peritonsillar abscess, tonsilleotomies, furuncles, influenza, and la grippe), from which there were no deaths but for which the same treatment was used, have been omitted, as have four diabetics—with pyonephrosis, apoplexy and pulmonary tuberculosis with ketosis, carbuncle and septicemia with ketosis, erysipelas with an extensive subcutaneous abscess of the scalp and generalized pyoderma, either moribund or hopelessly ill before this treatment was begun.

Of the 80 recorded cases, there were 7 deaths (8.7 per cent). One of these was due to lobar pneumonia, the only fatality in 11 consecutive cases (9 per cent mortality). While the pneumonia mortality rate is low, the frequency of complications—pleural effusion, empyema, and lung abscess—was higher than in nondiabetics.

Two deaths following major amputations were attributable to uremia and bronchopneumonia, and septicemia. One patient died following gastrostomy for carcinoma of the esophagus. At autopsy, an esophageal bronchial fistula was also found. One death occurred from hypostatic pneumonia following a series of furuncles and a large abscess of the scalp. The remaining two deaths were due to bronchopneumonia, uremia and gangrene, and bronchopneumonia, acute pyelitis, and ketosis.

SUMMARY AND CONCLUSION

Equal division and spacing of the diet and insulin is advocated for diabetic patients during the postoperative period, during acute infections, and for two or three days following attacks of diabetic coma because:

1. Of the simplicity of the plan and the ease with which the diabetes can be controlled.
2. There is less tendency to great fluctuation in the blood sugar, less tendency to ketosis, and less tendency to hypoglycemia.
3. Our results on this regime are in happy contrast to those when longer periods without food and insulin were allowed. Furthermore, we believe the results, the time factor, and the number of patients thus treated amply justify the treatment employed.

The slow absorption, the prolonged effect and the stabilizing influence that protamine insulinate has on the blood sugar were shown to advantage when this preparation was combined with the regular insulin treatment during convalescence.

The authors gratefully acknowledge the kind cooperation of Drs. C. Mitchell and W. E. Lee, the late E. Klopp, the late Thomas McCrae, John Gibbon, Sr., and John Flick in permitting this study to be made on their patients at the Jefferson and Pennsylvania Hospitals.

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PERFORATION OF THE GALLBLADDER

ANALYSIS OF FORTY-SIX CASES*

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THIS series of 46 perforations of the gallbladder which occurred in 886 operations for cholecystic disease, a percentage of 5.2, is being reported as a further argument for recognition of the high incidence of the complication and the urgent necessity for operation before its development.

In 1934, Eliason and McLaughlin gave a tabular review of cases of perforated gallbladder as published by several authors to that time, including figures of incidence and mortality. They showed that the incidence ranged from 0.9 to 2.5 per cent. The average mortality in cases of five authors whom they quoted was approximately 47 per cent. In addition, they reported their own series of 9 perforations found in 500 cases of gallbladder disease, an incidence of 1.8 per cent, with one death, or a mortality of 11 per cent.

Eight of the 46 patients in the group reported here died from complications having some bearing upon the operation, constituting a mortality of 17.4 per cent. In the 834 nonperforated cases there were, in addition, 2 probable perforations, 3 partial perforations, 25 in which the gallbladder was gangrenous, 28 in which pericholecystitis was a complication, and 9 in which local peritonitis had developed.

Of the total number of patients, 621 were women, and 265 were men; whereas, 22 of those whose gallbladder had perforated were women, and 24 were men. From this, it is apparent that the ratio of perforations is much higher in men. A similar finding has been reported by others, but no explanation has been offered for this peculiar circumstance.

TABLE I

PERFORATION OF THE GALLBLADDER: INCIDENCE AND MORTALITY

	NO. PERFORATIONS	INCIDENCE	DEATHS	MORTALITY
6,800 cases—five authors (quoted by Eliason and McLaughlin)	96	0.9 to 2.5%	-	42 to 52%
500 cases—reported by Eliason and McLaughlin	9	1.8%	1	11.0%
886 cases—reported by R. L. Sanders	46	5.2%	8	17.4%

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The average age of the men in whom perforation had taken place was 55 years, the oldest having been 73 years, the youngest 34 years. The ages of the women averaged 50 years; the oldest was 70 years, the youngest 23 years. The average age of the patients who died was 60 years.

The perforations of the gallbladder in this group are classified as (1) chronic, (2) subacute, and (3) acute according to the severity of symptoms, the activity of the process, and the duration of the present attack. In the infections regarded as chronic, recovery had taken place, all the local infection had been controlled, and the perforation had been well protected. Practically all the patients were ambulatory, and the operation could be classified as elective. The subacute cases were those in which the violence of the symptoms had been spent, the infection was abating, and the walling-off process was well under way, but in which it was evident from the course of the disease that the patients would not completely recover. The duration of the attacks in this group varied from a few days to two or three weeks. In the acute cases, the perforation had occurred recently and the infection was active, the time which had elapsed from the onset of symptoms to the operation having ranged from a few hours to three or four days.

The perforation was regarded as chronic in 13 cases, subacute in 11, and acute in 22. Of the total number of patients with chronic, subacute, and acute perforations, 22 had empyema of the gallbladder; frank pus was found in the gallbladder of another; in 9 patients the gallbladder was gangrenous; a marked pericholecystitis was present in 1, local peritonitis in 1, a spreading peritonitis in 2; and in 1, an intraperitoneal hemorrhage had taken place. In none of the patients had the intestinal tract been sufficiently involved to produce obstruction.

Stones, which were present in 42 of the 46 cases, were distributed as follows: gallbladder alone, 23; ducts alone, 6; and gallbladder and ducts, 13.

Cholecystectomy was performed in 36, partial cholecystectomy in 4, and cholecystostomy in 6 cases. Two of the patients on whom a cholecystectomy was done had previously had a cholecystostomy.

In addition to the gallbladder operation, one or more surgical procedures were carried out in 32 cases, in 5 of which 3 operations were performed. The common duct was opened in 11 cases, and the appendix was removed in 21. A separate McBurney incision was made in 4.

Nine of the 13 chronic perforations had entered the liver, producing localized abscesses. In one case, the opening was in the fundus and was protected by adhesions. In another, the gallbladder had perforated onto the stomach; this, also, was guarded by adhesions. Two

of the patients with chronic perforations developed complications which brought about death. One of these had a perforation into the duodenum, with adhesions about the fistula; a cholecystectomy and choledochotomy were done and the fistula repaired. The remaining patient had a perforation onto the stomach, which was protected by adhesions. The operation consisted of a partial cholecystectomy and choledochotomy.

Of the 11 subacute perforations, 7 had opened into the liver, 2 were protected by adhesions, and 1 had taken place into the abdominal wall, with subsequent rupture of the wall and drainage of stones to the surface. Another perforation of this group had entered the stomach and duodenum, forming two distinct fistulas, representing a spontaneous cholecystogastrostomy and cholecystoduodenostomy. Five of these patients had empyema with protected perforation. Stones were found in the gallbladder in all the subacute cases, and in the ducts in 5 cases. A choledochotomy, with removal of stones, was done in 3 of these.

Cholecystectomy was performed in 9 of the subacute cases, partial cholecystectomy in 1, and cholecystostomy in 1. In the case of perforation into the stomach and duodenum, it was necessary to do a partial resection of the stomach and remove the gallbladder at the same time, from which the patient failed to recover.

The perforation was regarded as acute in 22 cases. Eight of these were definitely protected by omentum, 3 had taken place into the liver, and 1 into the hepatic flexure of the colon; 2 had occurred at the juncture of the cystic duct and were protected by recent inflammatory tissue; 1 had perforated onto the duodenum; 3 had entered the general peritoneal cavity; 1 ruptured during manipulation while separating adhesions preparatory to removal of the gallbladder; and in 1 case there was a spontaneous separation of the gallbladder from its liver attachment and sloughing of the duct, permitting the gallbladder to be lifted out without effort. The blood supply was sufficiently

TABLE II
CLASSIFICATIONS

<i>Type:</i>	
Chronic	13
Subacute	11
Acute	22
<i>Stones:</i>	
Gallbladder alone	23
Ducts alone	6
Gallbladder and ducts	13
<i>Operation:</i>	
Cholecystectomy	36
Partial cholecystectomy	4
Cholecystostomy	6

damaged in 9 cases to produce gangrene. Stones were present in the gallbladder in 14, and in the duets in 9. The common duet was opened in only 2 cases.

The gallbladder was removed in 15 of the acute cases, a partial cholecystectomy was done in 2, and a cholecystostomy in 5. Five of the patients in this group died, making a total mortality of 22.7 per cent in the acute cases. It is obvious from this that operation was postponed too long after the onset of symptoms; earlier surgical intervention would have saved a greater number of these patients.

The symptoms of the 46 patients had persisted for varying periods, from a few days to thirty-five years. A history of previous symptoms of cholecystitis was obtained from 32 patients. Twenty-nine gave pain as the chief symptom in early attacks, and 15 of these had noted that it radiated to the scapular region; in 3, the pain was described as a hunger sensation. Five patients had had attacks of violent nausea and vomiting, while 8 had been bothered with gaseous distention. Chills, fever, and damage to the vascular system had occurred in several. Anorexia, constipation, and a mild jaundice had been noted in former attacks by one-fourth the group. Only 4 patients were seen in the first attack. One of these had been sick for a week, another for two weeks, and the remaining 2 for four and five weeks, respectively, before coming to surgery.

Many of the patients stated that the present attack was acute at the onset, became less severe for a day or two, then was exacerbated as peritonitis developed. In 35 cases, the average duration of the attack for which the operation was performed was two to three weeks. The symptoms had been present for twelve hours in the shortest, and in the longest, they had persisted, with alternating periods of mild discomfort, for six months. In the majority of cases of a prolonged history of the present attack, the perforation had, of course, become chronic. In a few, however, an acute perforation followed attacks lasting for several weeks. Multiple ruptures were found in 5 cases, the primary opening having been protected by adhesions and newly formed tissue.

Physical examination revealed that epigastric tenderness and muscular rigidity were present in practically every case and were exaggerated in those in which fairly extensive local peritonitis had developed. A definite mass was palpated in 15, and in the remainder there was thickening of the tissues. A mild or moderate leucocytosis was recorded in all the cases in which the blood cell count was made.

A correct preoperative diagnosis was made in 4 of the acute cases and was suspected in a few others. Cholecystitis, or empyema of the gallbladder, was the preoperative diagnosis in 35, obstructing duodenal ulcer with cholecystitis in 1, perforating duodenal ulcer in 1,

abscess of the abdominal wall secondary to gallbladder perforation in 1, and acutely inflammatory, high-lying appendix in 1. Three of the patients were submitted to exploration on an indeterminate diagnosis.

Only 14 of the entire number of patients with perforation had a roentgenologic study; 6 of these had a functionless gallbladder, the others, varying degrees of impairment. The diagnosis was sufficiently clear without the aid of a roentgenogram in the majority of cases.

The average duration of hospitalization of the 46 patients was 22 days; the briefest period was 10, the longest, 60 days.

In this series, there were 8 deaths which occurred following operation. In one other case, the wound had healed, bile was passing normally through the bowel, and the patient had recovered entirely from a cholecystectomy and choledochotomy. He was 71 years of age, had previously undergone a prostatic resection, and was handicapped by a damaged myocardium. A flare-up of the urinary tract infection weakened his condition and was responsible for his death, twenty-one days after operation.

A résumé of each of the 8 fatalities follows:

CASE 1.—A woman, aged 70 years, had been troubled with stomach disorder for thirty-five years, yet had never had an attack of acute colic. Recently her complaint had been a periodic burning, heavy sensation in the stomach and epigastrium, which began a few hours after meals and was relieved by the ingestion of food. She had not been jaundiced. The present attack was abrupt in onset, with severe pain, nausea, and vomiting as the chief symptoms. Twenty-four hours later her temperature was slightly elevated, and the right upper abdominal quadrant was tender and rigid; no mass could be palpated. The preoperative diagnosis was a probable perforated duodenal ulcer.

Exploration revealed a large, thick-walled gallbladder containing purulent material and many stones. A perforation was found near the liver border but was protected by omentum, which formed the wall of a fairly large abscess. The liver was congested and extended down four fingerbreadths below the costal margin. The appendix was subacutely inflamed and was removed. Cholecystectomy was performed, free drainage instituted, and the abdominal wall closed. The patient's condition was satisfactory for three days; both lungs then became congested, her temperature rose, delirium and disorientation followed, and she died on the fifth day postoperatively from bronchopneumonia and myocardial insufficiency.

CASE 2.—A woman, aged 65 years, gave a definite history of gallbladder disease covering a period of thirty years. Her distress had been more acute during the previous three years. Four weeks prior to the operation, she had had an attack of severe pain, nausea, vomiting, and fever, which had failed to subside completely. She had also lost weight and strength.

The patient's temperature was slightly elevated, and her blood cell count showed an increase in leucocytes. A large, tender mass was palpated in the gallbladder region, and a moderate muscular rigidity indicated local peritonitis. The preoperative diagnosis was acute empyema of the gallbladder with perforation.

At operation, the gallbladder was found to have perforated into the hepatic flexure of the colon, forming a cholecystocolic fistula. The gallbladder contained one large stone and purulent material. The liver border and contiguous tissues

were acutely inflamed; local peritonitis was extending; and a considerable quantity of infected free fluid filled the right upper quadrant of the abdomen.

The gallbladder was removed, the colon fistula repaired, free drainage established, and the abdomen closed. A blood transfusion was given at once. Following operation, there was a profuse and malodorous drainage, but it was apparent that much of the infectious material was being absorbed. The patient declined gradually and died ten days after operation from sepsis and exhaustion secondary to the long-standing disease.

CASE 3.—A man, aged 63 years, had had gallbladder symptoms intermittently for thirty years. The present attack had continued for ten days, having begun with a severe pain in the epigastrium, which radiated to the shoulder and was accompanied by gaseous distress and a rise of temperature. He had also been jaundiced and troubled with itching. In addition, he complained of some bladder retention.

A moderate tenderness over the upper abdomen was the only physical finding. The preoperative diagnosis was extrahepatic obstructive jaundice, probably caused by a stone in the common duct. Since the urinalysis revealed the presence of considerable pus, an in-dwelling catheter was used for two weeks, while a blood transfusion and other preoperative measures were carried out until the patient was in fit condition for exploration.

On opening the abdomen, the gallbladder was found to have perforated onto the pyloric end of the stomach, the perforation being protected by adhesions. Several stones were discovered in the abscess pocket, as well as in the gallbladder and common duct. A partial cholecystectomy was done, the common duct opened wide, the stones removed, and a T-tube inserted for drainage. Bile drained freely and the patient's convalescence was satisfactory for five days. Nausea, vomiting, and a decrease in the bile drainage then ensued for ten days, with a decline in his general condition. Intestinal obstruction was feared, but barium passed through the bowel, proving its patency. Following a blood transfusion, cellulitis with multiple abscesses appeared on his arm. On the twenty-sixth day after operation he developed bilateral bronchopneumonia and anuria, and died two days later.

CASE 4.—A man, aged 46 years, gave a history of intermittent attacks of epigastric pain, with an associated jaundice, during the previous five years. For ten months, his symptoms had been more severe, having indicated, at times, a peptic ulcer; at other times, they had been mixed, pointing to both ulcer and gallbladder disease. Coincidentally, he had gradually lost weight.

A moderate epigastric tenderness and a sense of thickening of the deep tissues were the only abnormal physical signs. The roentgenologist reported evidence of an obstructive lesion in the duodenum. The preoperative diagnosis was chronic cholecystitis and duodenal ulcer.

After two weeks of preparation, the abdomen was explored. The gallbladder was enlarged and subacutely inflamed and had perforated into the pyloric end of the stomach, as well as into the first and second portions of the duodenum, producing a natural cholecystogastrostomy and cholecystoduodenostomy. There was also a large gastric ulcer on the lesser curvature near the pylorus.

A cholecystectomy and partial gastrectomy were performed. The operation was extensive and prolonged, but in spite of this, the patient left the table in good condition, and his progress was satisfactory for twenty-four hours. He then became cyanotic, gasped, and died, presumably from pulmonary embolism.

CASE 5.—A man, aged 45 years, a stonecutter by occupation, had had a sub-sternal abscess in childhood and in recent years several attacks of bronchopneumonia;

the last attack, seven months previously, had been complicated by pleurisy with effusion. During the prolonged convalescence, he had been seized with an acute epigastric pain accompanied by nausea and vomiting, which gradually subsided. A second and similar seizure had begun forty-eight hours before the patient's admission to the hospital.

On palpation, the patient's entire upper abdomen was tender, and the muscles were rigid. He had an elevation of temperature, and the leucocytes numbered 12,500. The urine contained both albumin and casts. The preoperative diagnosis was acute cholecystitis, pneumoconiosis, and acute nephritis.

Abdominal exploration revealed large old blood clots under the liver margin about the gallbladder. The latter organ was increased in size and filled with bloody fluid, and its wall was gangrenous. In its fundus was a perforation from which the blood had escaped into the peritoneal cavity.

A cholecystostomy was done and the abdomen freely drained. Two days later the lung condition became reactivated, the nephritis grew worse, and death occurred on the third day following operation.

CASE 6.—A man, aged 70 years, had suffered with symptoms of gallbladder disease for seven years. Five weeks before admission to the hospital, he had had a severe biliary colic with irregular fever, and had since lost weight and strength. He was also aware of dyspnea on exertion.

It was obvious that the patient was greatly debilitated. Weak heart sounds and an irregular pulse were significant of a damaged myocardium. The blood cell count showed 19,200 leucocytes. Marked tenderness and a suggestive mass were noted in the gallbladder region, and distinct muscle spasm with some rigidity spread over the abdomen. The preoperative diagnosis was acute cholecystitis with empyema and stones, and myocardial insufficiency.

Operation was carried out under local anesthesia. The gallbladder was distended with purulent fluid but contained no stones. Its walls were gangrenous almost throughout, secondary to vascular damage and congestion of the lymph spaces. A perforation was found in the fundus, through which infectious material had leaked into a pocket formed by the omentum.

A cholecystostomy was done and thorough drainage instituted. Soon after the operation, the patient developed an uncontrollable hicough. He gradually declined and died on the sixth postoperative day. The cause of death was recorded as sepsis and myocardial insufficiency.

CASE 7.—A man, aged 59 years, had been seized with a violent, radiating epigastric pain, accompanied by nausea and vomiting, seven days before admission to the hospital. His condition was growing worse, and it was clear that a real intraabdominal catastrophe had occurred. This was his first attack; no history of previous gallbladder disease or biliary colic could be obtained.

The patient was acutely ill. Tenderness and muscular rigidity extended over the entire abdomen but were most pronounced over the gallbladder region and downward to the pelvis on the right. No mass was palpated. His temperature was slightly elevated, and the blood cell count revealed a moderate leucocytosis. The findings otherwise were not significant. The preoperative diagnosis was acute cholecystitis and acute appendicitis.

A high muscle-splitting incision was made rather far out to the right. A large amount of bile-stained fluid was seen to have gravitated along the outer side of the colon and into the pelvis. The appendix was not involved in his present complaint but was removed. A transverse incision was then made over the upper abdomen. The gallbladder was greatly distended and acutely inflamed; infected fluid was leaking from a small, unprotected perforation near the cystic duct. The blood

supply of the gallbladder was damaged but not destroyed. A local peritonitis involved the duodenum and contiguous tissue and apparently was spreading.

A cholecystectomy was done, ample drainage provided, and the abdomen was closed. Bile-stained fluid drained freely into the dressing but the patient grew increasingly restless; his temperature rose to 104.6 degrees; his pulse rate became rapid, irregular, and weak; and he died forty-eight hours after operation. An autopsy was not performed, but the causes of death were believed to be general peritonitis and acute myocardial insufficiency.

CASE 8.—A man, aged 61 years, had had several attacks of severe abdominal pain, which had begun nine years earlier and which had occurred at intervals for four years. During the following five years he had been free of discomfort until the present attack, two weeks before he entered the hospital. The onset had been sudden, with an excruciating pain in the epigastrium, which radiated to the shoulder. He had also had some fever and had been deeply jaundiced.

The abdomen was tender and tense; no mass could be palpated. The urinalysis indicated a mild infection of the urinary tract; otherwise, the examination was negative. The preoperative diagnosis was chronic cholecystitis.

At operation, the gallbladder was small and contained one large stone. It was adherent to the duodenum, into which it had perforated, forming a complete fistula. The common duct was opened and explored, but no stones were found. The head of the pancreas was nodular and inflamed and was probably responsible for the jaundice.

A cholecystectomy was done, the duodenum opening sutured, and the abdomen closed. The patient made good progress for a few days. He then began to grow weaker, and his urine output became increasingly less. All therapeutic measures failed to restore proper excretion, and he died twenty-two days postoperatively from uremia and exhaustion.

COMMENT

The proper time for operation in acute gallbladder disease has been much disputed. The main difficulty, in my opinion, is determining whether the condition is or is not acute. Even the keenest diagnostic acumen is fallible in discerning perforation in many instances. Those authors who have mentioned the matter have admitted that their preoperative diagnosis was correct in comparatively few cases of perforation of the gallbladder. As has been stated often, the symptoms are so variable in number and intensity that no certain syndrome can be regarded as pathognomonic of rupture until its devastating consequences become almost irreparable. Several cases of this series are proof that an acute perforation may be found when no history of an acute exacerbation of symptoms is given and the patient's condition is not extreme at examination. A scout film of the abdomen or fluoroscopic study may afford a clue to the diagnosis in revealing the presence of stones in the region of the gallbladder, but this is not entirely dependable. We know that perforation can and does take place when no stones are present. The four cases of gangrene with perforation mentioned in this series are examples.

Cases of chronic perforation are recognizable, as a rule, by a history of unchanging, more or less severe symptoms over an extended period. There is no need for delaying operation here. When acute symptoms have begun to subside, surgery should be postponed until further regression takes place. But if the patient's suffering is unduly prolonged or is increased, the condition may be considered acute, requiring immediate operation. Prompt surgery is indicated, of course, when persistent nausea and vomiting, weak pulse, increased respiration, an elevated leucocyte count, marked tenderness, and excruciating pain point to rupture into the peritoneal cavity.

In deciding the most opportune time for surgery, therefore, we can be guided only by present signs and symptoms. Operation may be elective in the apparently chronic cases, but it is imperative and urgent if symptoms already pronounced remain unchanged or become aggravated. Surgery may be postponed for a few days when there is evidence that the symptoms are subsiding or a possibility that they may do so under treatment. We agree with Behrend that, under proper control of a capable surgeon, there is little danger that an acute case of cholecystitis may go on to perforation; an exacerbation of symptoms may be readily detected and operation performed without delay.

It is generally conceded that cholecystectomy is the procedure of choice in gallbladder disease, when feasible. One material advantage of allowing acute symptoms time to subside lies in the fact that cholecystectomy usually may be done in the subacute stage, and thus the probable necessity for a second operation obviated.

In acute cholecystitis, when removal of the organ is contraindicated, Heyd and others have employed the method of bisecting the gallbladder from fundus to duct, enucleating the mucous membrane, inserting a tube, and closing the gallbladder about it. Heyd states that cholecystectomy is too dangerous and cholecystostomy alone often leads to the necessity for a second operation because of retention of an infected mucous membrane. Behrend believes the formation of adhesions the principal source of danger in a second operation. Both of these factors contribute to the hazard of cholecystectomy after cholecystostomy.

As was stated in the beginning, the whole purpose of this discussion is to dispel the illusion that perforation of the gallbladder is a negligible possibility and to bring to mind more forcibly the poor prognosis after its development. It is difficult to comprehend why, considering the dangerous potentialities, patients suffer with gallbladder symptoms for years before obtaining permanent relief. The fault cannot be attributed wholly to ignorance on the part of patients. Surely, many more are examined than are relieved. The responsibility lies

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Editorials

Intestinal Obstruction: The Present Status of the Problem

FACTS are wrested from nature often, only after an arduous struggle. To this difficulty in the acquisition of wisdom, bowel obstruction has been no exception. No divining rod has been available to indicate where truths lay hidden. Critical and accurately made observations subjected to the crucial test of direct experiment are the only means by which new and basic principles are added to our knowledge.

For decades, clinicians and investigators have wrestled with the intangibles of bowel obstruction. Out of their diligent labors have emanated a few simple, but fundamental, truths. On reflection, some of these appear almost self-evident. Is not the same often said of most new discoveries? Today we hear less of the alleged toxic factor in acute intestinal obstruction and more concerning the effects of prolonged obstruction upon the bowel wall. The significance of the loss of water and electrolytes through the agency of vomiting is generally appreciated. Long-continued intestinal occlusion gives rise to increases of intraluminal tension which may threaten the viability of the bowel wall and increase its permeability. In this manner, a new route may be opened up for absorption, against which the body has developed no effective defense—transperitoneal migration of noxious agents. As long as the intestinal mucosa remains viable, this lining of the intestinal cylinder, it would appear, affords us the same protection in the presence of bowel occlusion which it bestows bountifully upon us all every day. With the onset of obstruction, bacteria multiply in the intestine, and the amierobic character of the upper reaches of the upper gut becomes nonexistent. Belated recognition is also being accorded the blood loss factor which attends strangulating types of obstruction in which considerable blood may be lost into the infarcted segment of the bowel. In the avowal of these occurrences as consequences of obstruction, the therapeutic measures indicated are plainly suggested. (1) Adequate replacement of fluid loss by the liberal paraoral administration of saline solution in all instances in which vomiting has been a feature; (2) early relief of distention by measures which preserve the sterility of the peritoneal cavity; (3) restoration of blood loss by transfusion in strangulating obstructions. All these are matters of general agreement and need no amplification.

The manner in which relief of existing distention is to be attained is not so generally agreed upon. In the main, however, these differences

with us, then, who, realizing after a reasonable length of time that medical treatment is not curative, fail to see that our patients receive the benefit of surgery before the disease process progresses too far. An awakened conscientiousness on the part of medical men would seem to be largely effective in reducing the unnecessarily high number of perforated gallbladders and the appalling number of fatalities in their train.

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large or the small bowel. He may often not be able to decide to his entire satisfaction just how the bowel is obstructed.

"Acute abdomen" is not synonymous with necessity for exploratory laparotomy, though, sad to say, it has too long been. The advent of constant recourse to x-ray examination (scout and erect films) in the acute abdominal lesion of perplexing origin has contributed much to correct diagnosis. The report of the roentgenologist, uninstructed as to the patient's history and physical findings, however, is often misleading and without value. When the roentgen findings are reviewed in the light of the clinical aspects of the case, however, they attain real significance. Visualization of gaseous distention in segments of the bowel attains significant meaning when coordinated with the presence or absence of vomiting, intestinal colic, abdominal tenderness, and gastric retention. No clinical diagnosis of bowel obstruction is complete if roentgen examination has been omitted.

In colonic obstructions, vomiting is often absent altogether; likewise, employment of the duodenal tube and suction demonstrate that gastric retention of fluid is almost invariably absent. In obstructions of the small bowel, on the contrary, copious and frequent vomiting is usual. Fecal-like vomiting is common in acute obstruction of the small bowel, but it has never been observed by the writer in colonic obstructions. Strangulating obstructions, in which blood escapes into the peritoneal cavity, invariably present rebound tenderness in addition to *intestinal colic* which accompanies all mechanical obstructions. The revelations of the scout film, when properly harmonized with the clinical findings, afford a stamp of finality to the diagnosis upon which reliance may be placed.

Within the past few years, a new agent has entered the lists as a rival, contending with operation for honors in the relief of intestinal distention due to obstruction—suction applied to an indwelling duodenal tube. Those who have schooled themselves in the intricacies of the art of recognition of acute abdominal disease have found the method helpful and a satisfactory substitute for certain obstructions for which they were previously wont to perform operation. In adhesive, incomplete occlusions and in physiologic obstructions, the method has found its greatest usefulness. As an auxiliary to surgery, it has proved of value in most obstructions. Its limitations are quite understandable and the employment of suction applied to an inlying duodenal tube as the sole remedial agent is strictly contraindicated essentially in two kinds of obstruction: (1) strangulating obstructions, (2) occlusion of the left colon in which the competent proximal ileocolic sphincter limits the distention to the colon. He who essays to use the plan as a trial method in diverse conditions to determine whether operation will be necessary is likely to encounter difficulties. Moreover, mere cessation of *intestinal*

of opinion relate largely to the late case and the employment of compromise measures. To the early mechanical obstruction, by quite uniform consent, are applied the remedial measures of election. It is natural that amongst surgeons some controversy should hedge about the choice of procedure. It is equally fitting that as much thoughtful consideration be accorded the actual plan or design of an acceptable procedure. For undoubtedly the technique of execution of a procedure is fully as important and telling as is the choice of therapeutic expedient. Whether, in equally skilled and practiced hands, release of the bowel is secured by severing an obstructing band or performing enterostomy is often not an important issue. If, however, the bowel is punctured in freeing the gut or if the compromise measure of enterostomy is not *aseptically* done, the doom of the patient is sealed—not by the choice of remedial agent, but by the bungling of the surgeon. With release of the obstruction, no matter how great the distention, nor whether the obstructing agent be removed or only an exit be afforded for the removal of the retained gas and fluid, if the obstruction is simple in character and the bowel wall is intact and no visible soiling of the peritoneum has occurred, the outlook for the patient is promising. All strangulating obstructions operated upon early, with the single exception of thrombosis or embolism of the mesenteric vessels, may be treated as instances of simple obstruction after liberation of the constricting agent. In all instances in which the viability of the intestinal wall is lost, the threat to life is great. Operations for the relief of intestinal obstruction are accompanied by risk in so far as the sterility of the peritoneum has been vitiated by the condition of the bowel or violated by the surgeon. The operative procedure of least magnitude which will accomplish the desired end, when executed *aseptically* and with minimal trauma to the obstructed bowel, promises the patient the best chance for recovery.

The importance of early recognition of intestinal obstruction is acknowledged on every hand. There are obstructions, to be certain, which are notably difficult to recognize, such as an enteric intussusception or occlusion of the lumen of the bowel by a gallstone. Differentiation between an inflammatory intraperitoneal focus simultaneously interrupting the continuity of the bowel and a primary strangulating obstruction presents one of the most difficult problems in abdominal diagnosis and one which not uncommonly needs exploratory incision for its proper and safe solution. The larger number of bowel obstructions, however, can be accurately identified by a careful appraisal of the history, methodical employment of available criteria of physical examination, and the use of the scout film of the abdomen. When these findings are properly integrated, the examiner should be able to say with some confidence: (1) whether the bowel is obstructed; (2) whether the obstruction is simple or strangulating in character; and (3) whether it concerns the

blood for transfusion. The use of chronic syphilitics as donors, however, is a procedure not to be recommended except under most urgent circumstances and then only when blood from other sources is not available.

The serologic tests are not infallible indicators as to the presence or absence of *Treponema pallidum* in the donor's blood. The reactions may be positive when organisms are not present in the blood, as in chronic syphilis, and may be negative when the blood is teeming with *Treponema pallidum*, as in the incubation and seronegative stages of acute syphilis. The absence of recent exposure to syphilis and of chancre of skin or mucous membrane constitute our only guarantee against the existence of the latter circumstance in a prospective donor.

To avoid "transfusion syphilis" in emergency treatment one must, therefore, question the prospective donors relative to recent exposure, thus establishing facts relative to the possible existence of the stage of incubation, and one must examine for chancre (dark-field examination of any suspicious lesions), adenopathy, rash and mucous membrane lesions. If the history and these simple and readily made examinations are negative and the donor is not a pregnant woman, the very great probability is that syphilis, if present, is not in the acute stage and therefore not transmissible by blood transfusion. A careful, accurate history and examination of the body surfaces and orifices of the prospective blood donor are, therefore, more important than the serologic tests with donors' serum, valuable as these are. When reliance is placed solely on the Wassermann or Kahn test, false security may be encouraged even though the disease is present and transmissible to the recipient, as in the reported instances of "transfusion syphilis" induced by the use of donors in the incubation stage of the disease.⁴

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colic does not suffice to indicate that a satisfactory decompression is being achieved. Dependable information is to be obtained only by subsequent check-up scout films made at twelve- to twenty-four-hour intervals.

That progress has been made in the management of intestinal obstruction is attested in the recitals which appear in this issue of SURGERY from the pens of several men who have striven long with the problem. Wisdom is compounded of many experiences. Much yet remains to be learned. From the successes of these labors let us take courage and gird ourselves for a renewal of the conflict with the obstruction problem.

—Owen H. Wangensteen.

Transfusion Syphilis

IT IS well known that the virus of syphilis may be transmitted by blood transfusion. This *syphilis d'emblée* becomes apparent in from one to three or four months after the transfusion with the development in the recipient of the acute skin and mucous membrane lesions of the secondary stage of the infection. Although the literature contains relatively few case reports of such therapeutic accidents, they occur frequently enough to have become a part of the experience of most active hospital groups. The surgeon especially is likely to be *particeps criminis* since he commonly employs blood transfusions under circumstances of stress and emergency, when the detection of syphilis in the donor through careful questioning and physical and serologic examinations is difficult or impossible.

It is clear that the virus of syphilis must be present in the blood of the donor if transfusion is to result in syphilitic infection in the recipient. In experimental syphilis, it is known that the virus is present in the blood of rabbits during the acute or active phase of the infection and that with the disappearance of active lesions the blood loses its capacity to infect.¹ This would seem to be the case in the human disease. Eberson and Engman² injected blood from seventy-three individuals with chronic syphilis into rabbits' testicles and not a single infection resulted, although with similar technic blood from patients with acute syphilis regularly induces infection. There are several reported instances of the use of blood from donors with chronic syphilis for transfusions in which the disease was not transmitted to the recipients. A review of the reported instances of "transfusion syphilis" reveals that with one exception³ all of the donors either had acute syphilis or were pregnant syphilitic women. In this case it seems probable that the donor was experiencing relapsing, acute syphilis at the time he gave

nated, a certain minimal amount of water is required to carry them out. The healthy kidney can concentrate urine to a specific gravity of approximately 1.032. To carry out the average daily waste products (35 gm.) in a maximally concentrated urine, about 500 c.c. of water are required. When renal function is so impaired that the kidney has little or no concentrating power, about 1,500 c.c. of water are required.^{11, 12} If the water available for urine formation is inadequate to care for the removal of the waste products, these accumulate in the body fluids.

In the allotment of available fluid, the kidney is favored to a lesser degree than the other body tissues. The skin and lungs (water for vaporization), the gastrointestinal tract (diarrheas, vomiting, etc.) and the interstitial tissues (during edema formation) enjoy preferential rights over such fluid as is available, and their demands are satisfied first. The kidney uses the fluid which remains. The diversion of fluid for purposes other than urine formation has been called "prerenal deviation of fluids."¹³

These considerations have certain important implications. The most clinching evidence that the normal organism is not receiving enough water is the finding of a twenty-four-hour urine output of less than 500 c.c. If renal function is good, the urine will be highly concentrated (specific gravity 1.020 or higher). A small twenty-four-hour urine output with high specific gravity is (in the absence of edema formation) sufficient evidence for making a diagnosis of dehydration. As dehydration continues, beginning nitrogen retention may be noted. In extreme cases urinary secretion may cease completely. The skin is hot and dry; the urine is scanty and contains protein, red blood cells, and casts in greater than normal amounts; marked nitrogen retention augmented by urea from the increased protein catabolism in dehydration¹⁴ is usually present. Too frequently this syndrome is unjustly labeled toxic nephritis. The whole picture can be produced in normal persons by simply depriving them of fluid¹¹ and the remedy is, of course, administration of adequate quantities of fluid.

When the concentrating power of the kidney is reduced, the specific gravity of the urine of severely dehydrated patients will be lower than 1.020 (with maximal impairment, as low as 1.010) and the problem of determining whether the nitrogen retention is caused by dehydration or primary renal insufficiency may require further study. An approximate calculation of the fluid balance of the patient for a few preceding days may yield valuable information.

As will be indicated in the following sections, losses of water and salts, in excess of body economy, occur by way of the skin and gastrointestinal tract. Only rarely is the kidney the primary route for depletion of salt and fluid. Two well-known instances are diabetes mellitus and terminal nephritis. In the former, excessive urinary output of sugar and acidosis cause a profound diuresis with loss of body water and salts; in the latter,

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

THE USE OF PARENTERAL FLUIDS

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WATER is of utmost importance to the living organism. It forms part of every living cell and provides the medium in which the chemical reactions of the body occur. It constitutes more than one-half of the body by weight. Sir Arthur Shipley states that "even the Archbishop of Canterbury comprises 59 per cent of water."¹

Clinicians have long recognized that not infrequently the life of the patient depends upon the maintenance of an adequate water balance. New impetus to interest in problems of hydration has been furnished by the accurate and very practical studies of Newburgh, Collier, Maddock, and their coworkers.²⁻⁸ There are now available methods of calculating the fluid requirements of patients in all stages of fluid deprivation. It is the purpose of this paper to discuss the problem of hydration of patients with special reference to the physiologic considerations which determine the amounts and kinds of solutions to be administered.

Fluids are available to the body in the form of fluids ingested as such (about 1,500 c.c. per day), in the water content of solid food, and from water of oxidation. So-called solid foods are made up largely of water; e.g., a pound of steak will yield about 325 c.c. of water; the average maintenance diet supplies about 1,000 c.c. of water daily. Oxidation of the organic matter or of body tissues in starvation produces about 500 c.c. more.⁹⁻¹¹

In disease states it may not be possible or permissible to supply fluids by the gastrointestinal tract, and adequate fluid and salt intake becomes the physician's problem. Intelligent management of this problem depends upon an understanding of the nature and quantity of the fluid losses and the proper interpretation of the disturbed physiology produced by their loss.

In the normal individual water is lost from the body by three routes, viz., the kidney, the skin (and lungs), and the gastrointestinal tract. The burden of the excretion of several grams of waste products is thrown upon the kidney. In order that these waste products be entirely elimi-

The dehydrating effects of profuse sweating may be alleviated by oral administration of 0.2 per cent salt; if water is ingested without salt, the reduction of the osmotic pressure of the body fluids causes the onset of the syndrome known as miner's cramps.^{20, 21} If for some reason fluids cannot be taken by mouth, parenterally administered isotonic saline serves the same function admirably.

Glucose solutions cannot serve to replace the body losses due to profuse sweating because they do not supply the needed electrolytes and the water is not retained without salt to make it isotonic. Glucose solutions do, however, serve admirably as a source of water for vaporization needs which, in certain pathologic states, may be as great as 2,500 c.c. per day.^{2, 6}

The Gastrointestinal Tract as a Route of Depletion of Body Water and Electrolytes.—The fate of the digestive secretions is of prime importance in any consideration of body dehydration. The magnitude of the fluid and electrolyte mobilization is often underestimated and abnormal deviation of these fluids and electrolytes leads to clinical syndromes requiring more or less specific therapy necessarily based on the disturbed physiology.

The gastrointestinal tract consists of a hollow tube, the lumen of which is outside the body tissues. Into this canal are poured daily seven to ten liters of digestive juices. Secretion of these juices occurs almost entirely into the proximal portion of the canal. The juices (saliva, gastric juice, bile, pancreatic juice, and succus entericus) consist of water, electrolytes, and enzymes. They serve their functions in the canal and are propelled by the intestinal movements to the distal portions of the canal for reabsorption. The secretion and absorption of the digestive juices constitutes an internal circulation of great efficiency. By the time the intestinal contents have reached the sigmoid colon, the inspissated fecal material contains only a few cubic centimeters of water and small amounts of salts. The daily loss of water in the stool is about 100 c.c.

Two features of the internal circulation are significant from the standpoint of economy of body fluids and electrolytes:

1. The origin and chemical composition of the digestive secretions: The digestive fluids are derived from the blood serum and hence from the interstitial fluids with which they are approximately isotonic. The secretion of a liter of digestive secretion into the intestinal canal—lying outside the body tissues—is equivalent to depleting the body fluids of a liter of isotonic fluid. While the digestive secretions are isotonic with the serum electrolytes, they vary considerably in chemical composition; e.g., the gastric juice is richer in chloride and poorer in base than is serum. Secretion of gastric juice dehydrates the body and leaves the serum richer in base and poorer in chloride. Pancreatic juice con-

the damaged kidney is unable to economically regulate salt and fluid output. Since the incidence of primary renal depletion of salt and water is relatively small and requires consideration beyond the scope of this paper, these obligatory polyurias will not be discussed further.

The Skin (and Lungs) as a Route of Depletion of Body Water and Electrolytes.—Heat is lost from the skin and lungs by convection, conduction, radiation, and by evaporation of water. Heat lost by the evaporation of water is associated with loss of body fluid, the heat being dissipated in changing water from the liquid to the gaseous state. The water which is so vaporized, in the absence of visible perspiration, is called insensible water.¹⁶ The heat used in vaporizing this water amounts to about 24 per cent of the total heat eliminated from the body.⁸ Richardson¹⁷ has shown that this water loss is independent of the sweat glands, for about 28 per cent of the total heat was lost by vaporization of insensible water in a patient with congenital absence of the sweat glands. Thus, maintenance of a constant body temperature obliges an animal to lose a certain amount of water so that heat may be dissipated. This obligatory water loss in the normal individual amounts to 1,000 to 1,500 c.c. per day.² This water loss is associated with a negligible loss of electrolytes, for Benedict¹⁸ found that only 1.15 gm. of chloride were lost from the skin during a fasting period of 27 days.

When there is increased need for eliminating heat, the sweat glands function actively, elaborating fluid on the surface of the body. Evaporation of this fluid from the skin is effective in eliminating heat except when the sweat is lost from the body surface without being evaporated. Whereas, insensible water loss is of importance in calculating the fluid balance of the patient, it is never the primary cause of severe dehydration and depletion of body electrolytes. Such is not the case with the loss of fluids and electrolytes by the sweat.

Prolonged, profuse sweating can occasion the loss of tremendous quantities of fluid and electrolytes producing marked depletion of body salt and water.^{15, 20, 21} While the skin may exert some slight ability to spare body salt,¹⁵ its efficiency in this capacity is negligible. In profuse sweating as much as 2 gm. of sodium chloride may be lost from the skin per hour. The salt is excreted in a hypotonic solution (about 0.2 per cent sodium chloride²⁰). Since the sweat is derived from the serum, each liter of sweat depletes the body of a liter of water. Because the salt concentration of the secreted water is considerably less than that of the body fluids from which it was derived, there is more water lost than salt. The excessive amount of salt cannot be retained by the tissues without water to render it isotonic, so it is eliminated by the kidney with minimal loss of water.²² Ultimately then, a liter of sweat deprives the body fluids of a liter of isotonic saline. The electrolyte pattern of sweat resembles that of serum so that the loss of sweat is not associated with disturbances of the serum electrolyte pattern.

the canal—as occurs in the above mentioned pathologic states—the continued loss of gastric juice renders the serum poorer in chloride and richer in base and the tissue fluids are depleted of fluid and electrolytes. The production of this picture in pyloric obstruction may be seen in Table I. Total base is depleted; the chlorides drop to less than half their normal value; and the retained sodium combines with the carbonic acid formed during metabolic processes in tissues to increase the level of bicarbonate. Increases of bicarbonate to tetany levels (45 mm.) have been observed. In addition, vomiting is common and nutrition cannot be maintained so that carbohydrate deprivation and starvation ketosis may occur. The prerenal deviation of fluid may be of such magnitude as to leave too little water for adequate urinary volume and nitrogen retention may be present. The clinical picture includes: (1) dehydration, (2) depletion of body electrolytes, (3) imbalance of serum electrolytes (alkalosis), (4) starvation ketosis, and (5) azotemia.

Cases with achlorhydria will show the same picture with the exception that they do not develop alkalosis because sodium and chloride are lost in equivalent amounts.²⁹

Fluid therapy should include parenteral administration of saline solutions (to restore fluid, total electrolytes and to restore the electrolyte pattern) and glucose solutions (to relieve ketosis and excessive protein catabolism, supply ample fluids for urine formation to remove the accumulated nitrogenous wastes). Each type of fluid serves a specific function and both are needed to restore equilibrium. With an adequate supply of fluid the kidney quickly removes the nitrogenous wastes and corrects the electrolyte pattern by excreting sodium bicarbonate in the urine and retaining sodium chloride which the body needs.^{25, 26}

Similar serum electrolyte patterns and dehydration occur when the secreted juices are not vomited but are retained in the stomach and proximal portion of the gastrointestinal tract.^{27, 28} Their presence in the upper part of the tract is associated with marked nausea. Absorption of the secretions relieves the nausea and restores the serum electrolytes to normal.²⁸

TABLE II

A. COMPARISON OF CERTAIN ELECTROLYTES IN BLOOD SERUM AND IN THE DIGESTIVE SECRETIONS*

	Total Base	Cl	HCO ₃
	M-Eq	M-Eq	M-Eq
Serum	164	110	22
Fundus gastric juice	40	160	-
Pylorus gastric juice	188	142	-
Duodenum	177	120	-
Jejunum	155	150	20
Ileum	162	80	90
Colon	160	80	92
Pancreatic juice	168	115	45
Hepatic bile	182	90	45

*Modified from data in Peters' *Body Water*.³⁰

tains less chloride and more bicarbonate than serum, and secretion of pancreatic juice dehydrates the body and leaves the serum relatively richer in chloride and poorer in bicarbonate (Tables I and II).

2. The mechanics of the internal circulation make it vulnerable to pathologic variations associated with dehydration and electrolyte depletion:

a. Removal of secretions from the proximal portion of the gastrointestinal tract as occurs in vomiting, gastric and duodenal fistulas, high intestinal obstruction.

b. Failure of transport of the secretions to the absorptive area as occurs in ileus, acute gastric dilatation, intestinal obstructions.

c. Short-circuiting of the secretions to the outside as occurs in biliary, pancreatic, and intestinal fistulas.

d. Abnormal hyperactivity of the bowel as occurs in the diarrheas.

TABLE I

CHANGES IN GASTRIC JUICE AND SERUM ELECTROLYTES DURING DIGESTION AND PYLORIC OBSTRUCTION*

	Total Base	Cl	HCO ₃
	M-Eq	M-Eq	M-Eq
Gastric juice—fasting	95	155	-
Gastric juice during secretion	38	150	-
Serum electrolytes—normal dog	160	112	28
Serum electrolytes of same animal 66 hours after pyloric obstruction	138	90	38

*Modified from data of Gamble and McIver²⁰ and Gamble and Ross.²⁵

Because of differences in chemical composition, the loss of the digestive secretions proximal to the pylorus will produce body disturbances differing from those occasioned by the loss of digestive secretions secreted distal to the pylorus. The following considerations, bearing upon the continued loss of gastric juice, are of importance in considering the pathologic physiology of pyloric and high intestinal obstruction, gastric and duodenal fistulas, acute gastric dilatation, and vomiting.

The intimate relationship of the secretion of the gastric juice to the serum electrolytes is evidenced even during normal digestion. At such times, the gastric juice contains less base than fasting gastric juice (Table I). The variation in acidity is caused by the retention of base within the blood during secretion of the juice so that blood leaving the stomach is richer in base than blood coming to the stomach.²³ The extra base is excreted in the urine and accounts for the alkaline tide which is not observed in individuals with achlorhydria.²⁴ Under normal circumstances the acid gastric juice is neutralized distal to the pylorus and the fluid and electrolytes are reabsorbed to restore tissue losses. If now the transportation of the secreted gastric juice to the absorptive area is arrested or if the juice is ejected from the proximal portion of

In obstructions of the small intestine and in ileus, vomiting is usually a conspicuous feature and the loss of acid gastric juice may not only balance the bicarbonate losses of the other juices but may surpass them to produce the blood electrolyte pattern found in high intestine obstruction. The site of the obstruction, the extent to which absorption is impaired, and the nutritive state of the patient are uncontrolled factors which make prediction of the electrolyte pattern hazardous. If, however, the obstruction is distal to the absorptive area (at the level of the sigmoid colon), there may be little interference with the absorption of the digestive secretions and orally administered fluids.⁴⁰

Thus, disturbances of the gastrointestinal tract may lead to serious depletion of body fluid and electrolytes. When glucose solutions are administered, they provide water for vaporization and adequate urine output and carbohydrate to relieve ketosis and spare body protein; but when the sugar is utilized the water cannot be retained to replenish the depleted body stores because there is no salt to render it isotonic. From the standpoint of the body fluids and electrolytes, glucose solutions are useless for they neither replenish the body fluid nor the body electrolytes. For this purpose, saline solutions are indispensable. When the organism is well supplied with salt and water, the kidney exhibits a remarkable capacity to correct the electrolyte pattern. Excessive bicarbonate and diminished chlorides are cared for by retention of NaCl and excretion of NaHCO_3 in the urine; when base and bicarbonate are diminished and chlorides excessive, the NaHCO_3 is retained and the NaCl is excreted in the urine. The administration of additional bicarbonate in cases of chloride acidosis may be of some value.

While the normal obligatory water loss from the intestine is so small as to be negligible, in pathologic conditions associated with disturbances in fluid absorption, it may amount to several liters a day and constitute an important route of water and salt loss.

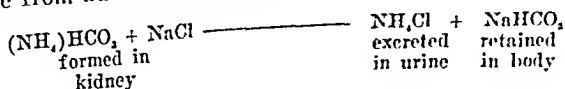
The Quantity and Quality of Fluids to Be Administered.—The quantity of fluid required by a normal individual is that amount which will supply the needs of vaporization and urine formation. It makes no difference to the body whether this amount of fluid is taken by mouth or is slowly administered parenterally in isotonic solution. The amount required per day is about 3,500 c.c. (vide infra). We are indebted to Coller and Maddock for a splendid solution of the problem of hydration requirements of patients with disorders of fluid balance. They found that the requirement of water for vaporization (for the regulation of body temperature) is about 1,000 to 1,500 c.c. in most patients, but under certain conditions (profuse sweating, hyperthyroidism) the amount needed may be as much as 2,500 c.c.^{41, 42} On the average, 2,000 c.c. is adequate for the vaporization needs of almost all patients.

Gamble and his coworkers³⁰⁻³² have shown that the total electrolyte concentration per unit of water in all the gastrointestinal secretions very closely approaches that in the blood serum. In Table II it may be seen that while the concentration of total base in the intestinal secretions below the pylorus very closely approaches that in serum, the pancreatic juice, hepatic bile, ileum and colon secretions contain increasing quantities of base combined with bicarbonate and decreasing amounts combined with chloride.³³ In general, the loss of the digestive juices of the small intestine and colon will entail the loss to the body of isotonic fluid containing total base and acid radicals made up predominantly of bicarbonate and to a lesser extent of chloride. Consequently imbalance of serum electrolytes occurs in which bicarbonate is depleted and chlorides may be normal or increased in concentration.

The above facts are of significance in interpreting the effects of the loss of these secretions in severe diarrheas and low intestinal fistulas. It has long been known that severe diarrheas (cholera, bacillary dysentery, amebic dysentery, diarrheas of infancy) may be the cause of serious dehydration. Fluids and electrolytes are hurried past the absorptive area so rapidly that absorption is at a minimum. The output of total base may greatly exceed the intake.³⁴ In low intestinal fistulas where fluid is short-circuited to the outside, the events are less acute but similar in direction.

While there is some controversy as to the incidence of hyperchloremia,³⁵⁻³⁸ it is agreed that dehydration, electrolyte depletion, and depletion of bicarbonate do occur. In addition, starvation ketosis and nitrogen retention may be present.

Saline solutions should be administered parenterally to replace body fluid and electrolytes and glucose solutions are needed for relieving ketosis and dehydration. Hartmann³⁷ believes that bicarbonate should also be given, for he found that saline and glucose alone do not restore bicarbonate to normal and may even exaggerate the chloride excess. Hoag and Marples,^{35, 36} on the other hand, find that if enough fluid is given to maintain adequate urinary output, there exists neither a need nor an indication for administering bicarbonate. Peters and van Slyke³⁹ sum up the matter by stating that "although bicarbonate may be of value in expediting the restoration of the normal electrolyte pattern by filling a specific deficiency, it seems to be less important than the establishment of normal kidney function by adequate supplies of water and salt. Bicarbonate can be produced in the body . . . chloride deficiency can only be met by administration of chloride." They suggest the following as a possible mechanism whereby the body restores depleted bicarbonate from administered saline:



rapidly and completely eliminated and that its elimination is associated with the loss of only a small amount of electrolytes. Thus, glucose solutions make ideal hydrating solutions, for they are not retained and they wash out negligible quantities of body salt.

An equal amount of isotonic salt solution given to normal individuals is only gradually eliminated "presumably because it causes minimal alteration of the composition of the serum."⁴⁰ Baird and Haldane⁴⁵ found that even healthy normal individuals will develop edema after the continued daily administration of 35 to 40 gm. of sodium chloride per day (an amount contained in about 3,500 c.c. isotonic saline). This finding alone should be sufficient to indict the common hospital practice of administering several liters of isotonic saline for several days to patients who have not lost salt but who merely require water to meet their hydration needs.

The more rapid retention of salt and water by sick patients constitutes a difference from healthy patients of degree rather than kind. Somewhat similar retention has been noted in pneumonia,⁴² tuberculosis,⁴³ and other conditions.⁴⁴ While impaired cardiac and renal function and low plasma proteins predispose to fluid and salt retention, these factors apparently played no rôle in the series observed by Coller, Dick, and Maddock.¹⁸ The incidence and dangers of edema of the parenchymatous and subcutaneous tissues following prolonged intravenous saline therapy have been noted by others.^{46, 47}

In view of the fact that electrolytes are not needed to satisfy the hydration requirements of this group of patients and may even produce edema in some, 3,500 c.c. of 5 per cent glucose may be used to advantage, for it supplies about 175 gm. carbohydrate to combat ketosis and spare body protein, and the water is ample for the needs of the skin and kidney. The continued administration of 5 per cent glucose is not associated with appreciable electrolyte loss, for Gamble, Ross, and Tisdall⁴⁸ have shown that in starvation, but without water deprivation, about 0.2 gm. sodium chloride is lost in the urine per day.

Group 2.—In this group are included those patients who are not dehydrated but who require parenteral fluids not only for normal hydration requirements but also to keep pace with abnormal fluid losses. Abnormal fluid losses include losses from the skin (excessive sweating), gastrointestinal tract (fistulas, vomiting, diarrhea, etc.) and the kidney (obligatory polyurias). The renal losses will not be discussed in this paper.

The skin losses due to excessive sweating require that some salt be replaced. Sweat is a hypotonic solution⁴⁹ containing about 0.2 per cent sodium chloride. As has been noted above, the salt left behind during sweating is excreted by the kidneys so that the end-result is the loss of a liter of isotonic saline for every liter of sweat. The losses from the gastrointestinal tract occasion the loss of fluids approximately iso-

The amount needed for urine formation (1,500 c.c.) was calculated from data supplied by Lashmet and Newburgh.¹² The latter found that with minimal concentrating power the kidney requires about 1,500 c.c. of water to eliminate the average amount of waste products (about 35 gm.). Although the normal kidney can eliminate this much waste in about one-third this volume of water, an allowance of 1,500 c.c. will cover all ranges of renal function. Thus 3,500 c.c. of water are needed per day to ensure hydration in patients who are not dehydrated and have no abnormal losses (vomiting, diarrhea, fistulas, etc.).

The quality of the fluid to be administered parenterally to supply the water needs of the body has been the subject of considerable study. Unsuccessful fluid therapy prevails when patients are not analyzed with reference to their hydration needs and there is a failure to appreciate the disturbed physiology. Two types of isotonic solutions are in common use:

- | | |
|--------------------|---------------------------------|
| 1. Sugar solutions | 5 per cent glucose in water |
| 2. Salt solutions | a. 0.9 per cent sodium chloride |
| | b. Ringer's solution |

Both types have their indications and limitations determined by the existing needs of the patient. The needs of patients are readily recognized if patients are classified as follows:

Group 1.—This group includes those patients who require water only to meet the requirements of water for vaporization and water for urine formation. Coller, Diek, and Maddock¹⁸ studied the effects of administration of both types of solutions to such a group "who had not lost appreciable amounts of sodium chloride but, because of their disease or because of treatment, could not or were not permitted to take sufficient fluids by mouth to maintain a normal water exchange." None of the patients were dehydrated; there were no abnormal losses; and most of them had little or no disturbance of the blood electrolyte pattern. The amount of each solution given was about 3,500 c.c. per day—2,000 c.c. for vaporization and 1,500 c.c. for urine formation. When 5 per cent glucose alone was given, all the patients lost weight because the caloric intake was below the requirement. When salt solutions were given for several days, the healthy patients did not retain salt and water but the sick patients did show evidence of water retention (by increase in body weight) even to the point of frank edema. Since these patients were not dehydrated, the retained water was not needed by the organism.

These results invite further consideration. When glucose solutions are administered, the carbohydrate is metabolized and the water is necessarily excreted because it does not contain salt to render it isotonic. Because the carbohydrate is metabolized, the administration of glucose solutions really means the administration of water to the organism. Strauss⁴¹ has shown that water administered to normal individuals is

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tonic with the blood serum. They should be accurately measured and replaced liter for liter by the parenteral administration of isotonic saline. Glucose solutions are useless for these purposes, for while they supply water for vaporization and urine formation, they do not relieve the underlying defect—a need for electrolytes and retained fluid to restore the body water and electrolytes and the electrolyte pattern. The mechanism by which this is accomplished has been discussed in a preceding section of this paper. Patients in Group 2 will require not only 3,500 c.c. 5 per cent glucose to maintain hydration but also should have their losses due to prerenal deviation of fluids made good by an equivalent amount of saline.

Group 3.—This group includes all patients who are dehydrated. In an investigation of the amount of fluid which must be lost from the normal body to produce the syndrome of dehydration, Maddock and Collier¹¹ found that dehydration symptoms, including scanty urine of high concentration and beginning nitrogen retention, appear when approximately 6 per cent of the body weight has been lost. On this basis, they calculate that a dehydrated patient weighing sixty kilograms requires 3,600 c.c. of fluid to rehydrate his body tissues. Fluid deprivation to the point of dehydration from any cause is always associated with salt loss. The quota necessary to rehydrate the patient should be supplied by isotonic saline. Thus, in the first twenty-four hours, the above patient will require 3,600 c.c. isotonic saline for rehydration and 3,500 c.c. 5 per cent glucose to maintain hydration (as in Group 1); if there are abnormal losses, additional saline may be required (as in Group 2).

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Review of Recent Meetings

REPORT OF THE MEETING OF THE AMERICAN ASSOCIATION FOR CANCER RESEARCH, CHICAGO, ILL., MARCH 24, 1937

E. T. BELL, M.D., MINNEAPOLIS, MINN.

(From the Department of Pathology, the University of Minnesota)

1, Dr. Wm. H. Woglom. In his presidential address, Dr. Woglom discussed the mechanism of immunity to a transplanted sarcoma in rats. In rats which recover from a transplanted tumor, the growth increases until about the tenth day, after which it gradually recedes. In such animals, he obtained an immune body from the spleen which inhibited the growth of the tumor when incubated with it for some time. He demonstrated that a water-soluble, immune body was found in the spleen.

2, Dr. E. T. Bell and Dr. T. P. Rothnem. Two brothers, aged sixteen and thirteen years, developed extensive squamous cell carcinoma of the lower lip on the basis of xeroderma pigmentosum. The skin of the face, neck, and hands showed a mild degree of the disease. The tumors of the lip were apparently completely cured by x-ray treatment.

3, Dr. Edgar H. Norris. A large benign thymoma was found in a case of myasthenia gravis. The thymoma was interpreted as a localized hyperplasia of the thymus.

4, Dr. Arthur H. Wells. A classic case of pheochromocytoma of the adrenal was reported. The classic picture of paroxysmal hypertension was present. The tumor was found at postmortem. The literature contains nine reports in which paroxysmal hypertension was cured by removal of a benign pheochromocytoma of the adrenal.

5, Dr. John J. Bittner. Dr. Bittner reported a highly interesting study on the spontaneous carcinoma of the breast in mice. It had already been shown that mating of a female from a high cancer strain with a male of a low cancer strain gave a high incidence of carcinoma of the breast in the offspring, while mating of a high cancer strain male with a low cancer strain female gave a low incidence of carcinoma of the breast. The incidence of carcinoma of the breast in the adult breeding females of the high cancer strain was about 83 per cent. When the young of the high cancer strain are transferred immediately after birth and are nursed by a foster mother of a low cancer strain, the incidence of spontaneous carcinoma of the breast in these mice was markedly reduced. This low cancer incidence had persisted for seven generations. The author suggested that the stimulus to cancer was transmitted by the milk.

6, Dr. Albert E. Casey. Dr. Casey studied various malignant diseases of the lymphatic system and concluded that the length of life was inversely proportional to the percentage of mitoses found in microscopic sections. He estimated the percentage of mitoses by counting 1,000 nuclei.

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AMERICAN ASSOCIATION OF PATHOLOGISTS AND
BACTERIOLOGISTS, CHICAGO, ILL., MARCH 25 TO 26, 1937

E. T. BELL, M.D., MINNEAPOLIS, MINN.

(From the Department of Pathology, the University of Minnesota)

1, Dr. John Howe. Dr. Howe found marked variations in the reaction to tuberculin from time to time in the same individual. He thought that the more intense reactions occur with the lower levels of diastolic blood pressure.

2, Dr. Max B. Lurie. Dr. Lurie found that in experimental inflammation in a tuberculous animal the exudate consists largely of mononuclear cells, even though the reaction of the exudate was alkaline. Menkin had noted previously that in the early phases of inflammation the reaction is alkaline and the exudate consists largely of polymorphonuclear leucocytes, but later the reaction became acid and the polymorphonuclears were replaced by mononuclears. Lurie found that this did not occur in the tuberculous animals.

3, Dr. C. E. Woodruff and Dr. H. S. Willis. Guinea pigs were inoculated with virulent tubercle bacilli, after which they became allergic. One group was desensitized with tuberculin. They found that the desensitized animals did not live as long as the allergic controls.

4, Dr. Albert B. Sabin and Dr. Peter K. Olitsky. The authors studied the route of extension of stomatitis virus and the virus of equine encephalomyelitis. Mice were inoculated in various parts of the body and the route of extension to the central nervous system was determined. When inoculated intranasally, the virus goes through the olfactory nerves to the brain and follows the olfactory pathways in the cortex. After intraocular inoculation, it travels to the opposite colliculus. The route of the virus in the brain is so definite that it affords a means of identifying intracranial nerve tracts. After intramuscular inoculation, the stomatitis virus goes by the peripheral nerves to the central nervous system. The virus of equine encephalomyelitis passes from any intramuscular site by the blood stream to the mucosa of the nose and thence by the olfactory paths to the brain. Application of tannic acid to the nasal mucosa prevents the development of equine encephalomyelitis after an intramuscular inoculation. Apparently the viruses spread along the axones of the nerve fibers.

5, Dr. Cornelius S. Hagerty. Dr. Hagerty produced embolic glomerular lesions by intravenous injections of fats and salts. In one type of lesion there was an endothelial proliferation and in another there was formation of collagen in the glomerulus. The author thought that the collagen was derived from fibrocytes which were present in the glomerulus.

6, Dr. Benjamin Castleman and Dr. Tracy B. Mallory. The authors reported ten new examples of adenoma of the parathyroid glands and two cases of diffuse hyperplasia. In the case of adenoma, a single gland is involved. These may be cured by removing the adenoma. Diffuse hyperplasias involve all of the parathyroid bodies and are secondary to some metabolic disturbances. Removal of such parathyroids does not bring about a cure of the hyperparathyroidism. In uremia, they found parathyroid hyperplasia of the diffuse type. This was attributed to the decrease of blood calcium, which in turn is caused by the retention of phosphates by the insufficient kidneys.

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7, Dr. Austin M. Brues and Dr. Elizabeth B. Jackson. It was shown that colchicine applied to growing tissues increases the number of visible mitotic figures by preventing the formation of the spindle. The chromosomes become scattered through the cell and cell division does not occur. This causes an increase of the number of cells seen in mitoses at any one time.

8, Dr. William S. Murray. Dr. Murray studied the effects of parabiosis in mice of a strain which had a very high incidence of spontaneous carcinoma of the breast. Parabiotic pairs were made by anastomosing male and female mice at the age of one month. There was good intermingling of the circulation. There was a very high mortality up until a period of three months, after which they became adjusted, and a number were observed for one year or more. He noted that the females go through an almost constant estrus. There is a very marked hypertrophy of the ovarian follicles, but after a few months the follicles begin to degenerate. The testes were inhibited only slightly in their development. No corpora lutea were found. The female breast did not develop. No cases of cancer of the breast occurred. Apparently the male hormone suppresses the action of the female hormone.

9, Dr. C. C. Little. Dr. Little discussed the genesis of structural abnormalities in a black strain of mice. He noted that some abnormalities follow a simple mendelian inheritance and that others follow a mendelian inheritance with some variation. The third group is inherited irregularly, and in the fourth group there is little or no genetic influence and the abnormality is interpreted as a somatic variation. The cancers, in general, follow mendelian inheritance with some variations. A large number of abnormalities appear sporadically in a supposedly genetically homogeneous strain. He believes that these rare abnormalities are not determined by genes.

10, Dr. Maud Slye. Dr. Slye gave the results of many years of study on the inheritance of cancer in mice. She believes that the development of cancer is determined by a unit recessive factor. One factor determines the type of cancer and the other factor determines its location. In a very large amount of material she found that the actual incidence of cancer corresponded rather closely to the predicted incidence.

15, Dr. W. C. Hueper and Dr. H. D. Wolfe. Dr. Hueper produced aniline tumors in the bladders of dogs. Some of the papillomas developed into carcinomas. The chemicals were given by mouth.

16, Dr. Balduin Lucké. Dr. Lucké has seen 500 examples of carcinoma in the frog's kidneys. The tumor always develops in the kidney and is structurally an adenocarcinoma. It shows large cell inclusions in the nuclei. Some of the tumors produce metastases. The tumor grows easily in vitro and the tumor cells outgrow the fibroblasts. No cell inclusions were seen in the cells of the cultures. Transplants do not seem to survive well except in the kidney, in which organ it is readily transplantable. This tumor occurs in frogs in the region of Chicago as well as in New England.

17, Dr. Caspar G. Burn, Dr. Aline U. Orten, and Dr. Arthur H. Smith. Dr. Burn and his associates maintained rats for a long time on a diet markedly deficient in vitamin A. They developed xerophthalmia and cornification of the vagina. A massive enlargement of the jaws was obtained, which was due to the formation of large odontomas. It appeared that these growths were not neoplasms in the strict sense, but an irregular growth of the teeth.

18, Dr. Robert A. Moore and Dr. Robert H. Melchionna. Dr. Moore injected the prostate of animals with 5 per cent benzopyrene in lard. After four or five months large prostatic cancers developed. The cancers were for the most part squamous cell carcinomas, but a few sarcomas were obtained. Seventy per cent of the growths appeared after one hundred fifty days. Castration had no effect. The lard alone gives only a foreign body reaction. The squamous cells arise by metaplasia of the glandular epithelium. He thinks that the sarcomas arise from the muscle.

19, Dr. Carl V. Weller. Dr. Weller gave a general survey of the influence of heredity in the genesis of tumors. He showed that in a few types of tumors, notably retinoblastomas, the hereditary intrinsic factor is of great importance. The behavior of this particular tumor suggests that it is determined largely by intrinsic factors and that extrinsic factors are of little importance. He concluded that cancer depends for its development on both intrinsic and extrinsic factors and that the importance of these two influences varies in different types of tumors.

20, Dr. S. Burt Wolbach. Dr. Wolbach reported a detailed study of the histogenesis of experimental tar tumors. He illustrated the various stages in the development of the carcinomas from a stage of simple chronic inflammation to a definite carcinoma.

21, Dr. Peyton Rous. Dr. Rous gave a survey of the relation of filterable agents to the formation of tumors. His most interesting experiment was obtained as follows: The ears of a rabbit were tarred for about three months. This does not produce a neoplasm. In order to obtain carcinoma of the rabbit's ear, the tarring must be continued for a very long time. However, when the ears were tarred for about three months and the rabbit was then given an intravenous injection of the Shoppe papilloma virus, extensive squamous cell carcinoma developed in both ears. This experiment shows that the virus attacks cells which have been injured by tar and quickly leads to the formation of carcinoma.

22, Dr. Leo Loeb. Dr. Loeb gave an excellent survey of the relation of the sex hormones to tumors. Loeb did the pioneer investigations in this field and he surveyed the various lines of work which have been followed in recent years.

7, Dr. H. Edward MacMahon. Dr. MacMahon demonstrated numerous mitoses in the cardiac muscle fibers of children under the age of two years. He offered evidence that there may be an increase in the number of cardiac muscle fibers after birth. The general impression of pathologists has been that the cardiac muscle fibers do not increase in number in postnatal life.

8, Dr. Alexander Nedzel. Dr. Nedzel produced lesions of the heart valves in dogs by injections of pitressin. In one group of animals, he used pitressin only and obtained an increase of cells and fibers in the heart valves. When bacterin (staphylococci or streptococci) were introduced intravenously in animals which had been injected with pitressin, he found that the organisms invaded the leaflets from their surfaces. The common opinion is that bacteria invade the valves from within, but Nedzel shows that the invasion apparently takes place from the surface. He was able to obtain a definite fibrosis of the valves and the proliferative type of inflammation from the use of pitressin alone.

9, Dr. Sidney Farber. Dr. Farber cut the vagus nerves in guinea pigs and rabbits. In both instances, the animals died of pulmonary edema, the guinea pigs in four or five hours, the rabbits in eight to thirty hours. A severe dyspnea develops and the alveoli fill with fluid. There is intense congestion of the veins and capillaries in the lungs and a variable amount of bronchopneumonia. The effect is something like a bulbar paralysis. He was able to exclude the larynx as a causative factor in the edema, since with artificial respiration through a tracheal cannula, the same pathologic picture developed. He believes that the most important factor in the edema is loss of vasomotor control.

10, Dr. Vally Menkin. Dr. Menkin reported further studies of the substance which he has isolated from areas of acute inflammation. This substance may be crystallized out. It is dialyzable and heat stable. He thinks it may be a polypeptide. When this substance is injected into normal areas of skin, it provokes increased capillary permeability.

11, Dr. Milton C. Winternitz, Dr. R. M. Thomas, and Dr. P. M. LeCompte. Dr. Winternitz reported an excellent study of the vasa vasorum. He showed numerous illustrations of the manner in which the blood vessels in the wall of an artery are distributed to its various layers. Evidence was offered which suggests that arteriosclerosis may be related to disturbances in the vascularity of the wall of the artery itself.

12, Dr. Graham Ross, Dr. Theodore R. Waugh, and Dr. H. Tait Malloy. The authors studied icterus neonatorum. They concluded that this is not a pure hemolytic change. They found no evidence in the blood of excessive hemopoietic activity. No complete explanation of the jaundice was found.

On the morning of March 26 a symposium on cancer was held by the Association of Pathologists and Bacteriologists.

13, Dr. Arthur J. Vorwald and Dr. John W. Karr. In a study of pneumoconiosis, the authors decided that there is no increased incidence in carcinoma of the lung in association with any form of pneumoconiosis. The carcinomas of the lung that occur in the Schneeberg miners develop on a basis of pneumoconiosis due to a radioactive dust.

14, Dr. M. J. Shear. Dr. Shear reported his studies on the carcinogenic activity of methyl derivatives of 1, 2-benzanthracene. He found that both cholanthrene and methyl-cholanthrene are highly carcinogenic and produce tumors within three or four months. For carcinogenic activity it is not necessary that the methyl group should be in position 6. He discussed the relation of chemical structure to carcinogenesis.

parathyroids, and thymus. Other sections deal with evidence for considering the pars intermedia, pars tuberalis, and pars neuralis of the posterior lobe as true internal secretory structures. The melanophore-expanding substance of the pars intermedia can be extracted from the mammalian as well as from the amphibian pituitary, but the suggested rôle of such a "pigment hormone" in connection with the visual function in mammals has not as yet been established. Regarding the posterior lobe in mammals, the author concludes that, "extirpation experiments offer little support for the belief that the pars neuralis is physiologically important." Nevertheless, it is recognized that the two active substances which can be extracted from it; namely, the oxytocic and the pressor or diuretic-antidiuretic principles, exert striking pharmacologic effects and so may serve emergency functions in the intact animal.

A unique and helpful feature of the book is an appendix which gives a classified list of the scientific and commercial names of all of the known hormones and hormone preparations. The known structural formulas of the hormones are also given.

Of the more than five thousand papers reviewed by the author, three thousand are listed alphabetically in the bibliography under their complete titles. This constitutes one of the most valuable features of the monograph.

Operative Surgery. By J. Shelton Horsley and Isaac A. Bigger. Two vols. Ed. 4. Pp. 1,387, with 1,259 illustrations. St. Louis, 1937, The C. V. Mosby Co. \$10.

Dr. Horsley, in revising material for the fourth edition of this text, was aware of the numerous difficulties besetting a single author in attempting to cover the entire scope of operative surgery adequately. He accordingly associated as co-authors surgeons of unquestionable repute who were not only trained in general surgery, but who had also devoted their efforts to various specialties. The co-authorship was allocated to Dr. Bigger, and the contributing authors were selected by these two men.

The fourth edition appears for the first time in two volumes, necessitated by the addition of new concepts of surgery and the inclusion of new material. The plan of the book duplicates that of its predecessors. All operative procedures presented are based upon established anatomic and physiologic principles, stressing that the aim of the surgeon should not be confined to meticulous and beautiful dissections of anatomic landmarks alone, but should also be directed toward the establishment of normally functioning organs postoperatively, as well as adequate removal of the pathology.

The indications, contraindications, advantages, and disadvantages for the various technical procedures are carefully outlined, followed by a discussion of the types of operations which, used by the authors, have produced the best results. In cases in which they believe that two or more procedures are adequate, they are likewise presented, the choice then being for the reader to decide as best suits his individual case. It is not a text of theoretic procedures, unproved and unaccepted, but instead a presentation of those procedures which the authors themselves performed and accepted as best for the restoration of the patient to a normal existence.

Each specialty of surgery is covered, and the newer procedures, such as those in the sympathetic nervous system and chest, are included. The reader may not agree with the choice of technique in some instances, and may believe that certain described methods could be replaced. Especially is this true in the chapter on transfusion, wherein the Lindemann method is emphasized and simpler methods omitted.

Book Reviews

The Physiology and Pharmacology of the Pituitary Body. By H. B. Van Dyke. Cloth. Pp. 577, with 55 illustrations. Chicago, 1936, The University of Chicago Press. \$4.50.

Under the above title, the author, an active investigator in the field of pituitary physiology and pharmacology, has presented the most admirable monograph on the subject that has yet come to the reviewer's attention. Because of its completeness and up-to-dateness, the volume should be invaluable to clinicians as well as to teachers and research workers who are interested in the complex problems involving this important gland. In spite of the enormity of the task of sifting the essential data from several thousand original papers, the author has presented a comprehensive and critical résumé of the literature with amazing brevity and clearness. Well-established facts are catalogued in their proper sequence without unnecessary repetition. Controversial or incomplete data are presented fairly and in such a manner as to stimulate further investigation. The printing and illustrations are in keeping with the high quality of the text.

Because of the multiplicity of functions attributed to the pituitary body and the many interrelationships between it and other glands of internal secretion, a monograph on this subject must necessarily deal to some extent with the physiology and functional pathology of most of the other units of the endocrine system. Therefore, the general field of metabolism and such specialized but closely related fields as the physiology of reproduction are discussed with reference to their direct or indirect relationship to the pituitary. Clinical data are included, in so far as they contribute to the elucidation of the underlying pituitary physiology.

The first chapter of the book appropriately deals with the anatomy of the gland from the points of view of its embryology and comparative anatomy. Under this chapter such important features as the blood supply, lymph drainage, and nerve supply are detailed along with adequate descriptions of the histology of the pars glandularis, pars intermedia, pars tuberalis, and pars neuralis. The physiologic anatomy, as affected by such factors as pregnancy, castration, and hibernation, is clearly outlined. The probable sources of the known hormones from specific cells and their possible routes of transport from the gland are discussed.

The succeeding chapters deal with the physiologic, pharmacologic, and clinical aspects of the subject. Throughout the text, the confusing variations in functions of the gland at different levels in the animal scale are brought out by separate discussions for fish, amphibia, reptiles, birds, and mammals. The characteristic anatomic and physiologic effects of removal of the entire gland or of its separate parts are recorded for different animal species. Conversely, the effects on the pituitary body itself of removal of other glands, such as the thyroid, adrenals, pancreas and gonads, are reviewed. The rôle of the hypothalamus in functions attributed to the pituitary, particularly as regards the control of water, mineral, carbohydrate, and fat metabolism, is discussed fully, and gaps in our knowledge regarding this important question are pointed out. Special chapters are devoted to discussions regarding the growth-promoting, gonadotropic, lactogenic, and thyrotropic hormones and to interrelationships between the pars glandularis and the adrenals, pancreas,

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The bibliographies at the end of each chapter are short and well chosen, but in many references the page numbers are lacking. The illustrations, most of which are original and made especially for this book, are beautifully done. They are delicate and successful, combining a realistic quality with the diagrammatic.

As a reference book it is lacking in that only certain chosen surgical procedures are listed, and numerous others are omitted.

The book is best described as a monograph presenting the authors' choice and reasons for their personal selections.

Books Received

The receipt of books is acknowledged in this section and this statement must be regarded as sufficient acknowledgment of the courtesy of the sender. Selections will be made for more extensive review dictated by the interests of our readers and as space permits.

INHALATION ANESTHESIA: A FUNDAMENTAL GUIDE. By Arthur E. Goedel, Associate Clinical Professor of Surgery (Anesthesia), University of Southern California. Macmillan Surgical Monographs, Elliott C. Cutler, editor. Cloth. Price \$2.50. Pp. 172. New York, 1937, The Macmillan Company.

PREOPERATIVE AND POSTOPERATIVE TREATMENT. By Robert L. Mason, Assistant in Surgery at the Massachusetts General Hospital. Cloth. Price \$6.00. Pp. 495, with 123 illustrations. Philadelphia, 1937, W. B. Saunders Company.

ANLEITUNG ZUR SCHMERZBETÄUBUNG, Kurzes Lehrbuch der Lokalanästhesie, Allgemeinnarkose und sonstiger Anwendung der Betäubungsverfahren. By Fritz F. Härtel, Director of the Division of Surgery of Oskar-Ziethen-Krankenhauses Berlin-Lichtenberg; unter Mitwirkung von Dr. Horst Jencio. Pamphlet, price 10 M.; Bound, price, 11.50 M. Pp. 106, with 17 illustrations. Dresden, 1936, Theodor Steinkopff.

CHRISTIAN R. HOLMES: MAN AND PHYSICIAN. By Martin Fischer, University of Cincinnati. Cloth. Price \$4. Springfield, Ill., 1937, Charles C. Thomas, Publisher.

DIABETES: A MODERN MANUAL. By Anthony M. Sindoni; introduction by Morris Fishbein; foreword by George Morris Piersol. Whittlesey House Health Series, Morris Fishbein, editor. Cloth. Price \$2. Pp. 240. New York, 1937, Whittlesey House, McGraw-Hill Book Company.

A MANUAL OF RADIOLOGICAL DIAGNOSIS. For students and general practitioners. By Ivan C. C. Telaperoff, Assistant Radiologist and Radium Registrar, St. Thomas' Hospital, London. With foreword by Philip H. Mitchiner. Cloth. Price \$6. Pp. 256, with 286 illustrations. Baltimore, 1937, William Wood & Company.

DIAGNOSTIC ROENTGENOLOGY. Ross Golden, editor. Fabrikoid. Price \$20. Pp. 854, with 964 illustrations. New York, 1936, Thomas Nelson & Sons.

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